Chapter V
Substitute Comparative Assessment, Screen Reclamation Methods

Introduction

Chapter 5 provides a comprehensive assessment of screen reclamation methods 1-4 and the automatic screen washer. When available, information is provided for each method and technology on occupational exposure and risk, population exposure and risk, performance of traditional and alternative systems, and the cost analysis of traditional and alternative systems. The discussion of the details of each method or technology includes an explanation of the particular advantages or disadvantages of that method or technology. The details, assumptions and uncertainties of each of the methodologies in this chapter are discussed in Chapter 3; referencing this chapter while reading Chapter 5 may eliminate the confusion that may occur due to the numerous exhibits.

Method 1: Traditional Reclamation

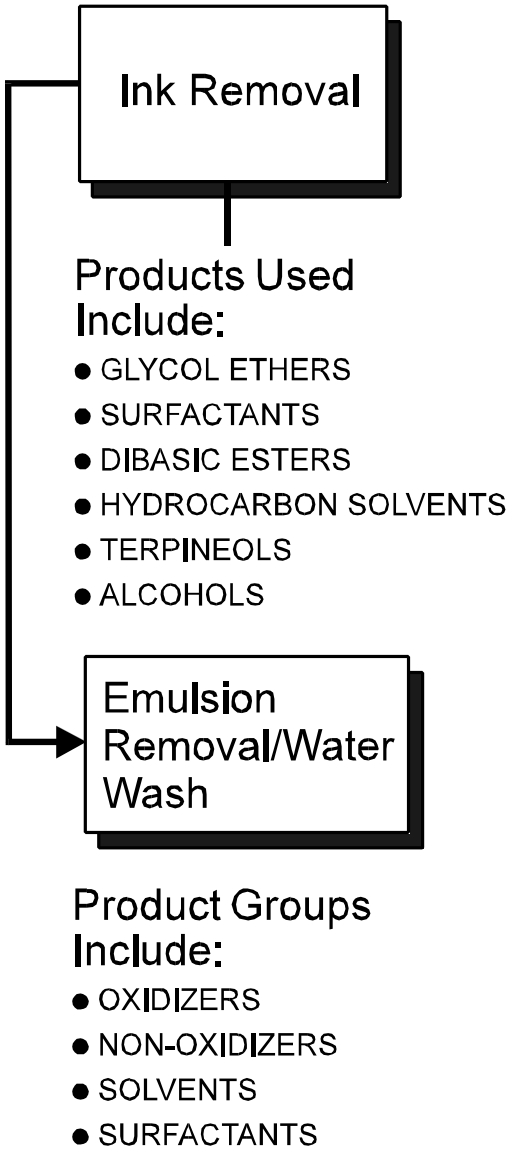
Method 1 encompasses the use of only ink removal and emulsion removal chemical products to reclaim screens. The action of these two products must eliminate the use of a haze remover. Some screen printers are able to reclaim screens without the need for a haze remover. Because a haze remover is not used in screen reclamation in Method 1, source reduction, the highest priority in the pollution prevention hierarchy, is achieved. However, simply because the haze remover is not used does not mean that occupational and population risk is low. The intrinsic hazard of the particular chemicals used in ink and emulsion remover products must be combined with worker and general exposure to the chemicals to generate a risk assessment. In the following discussion of Method 1, data detailing occupational and population exposure are presented to support overall risk conclusions for 6 systems comprised of only ink and emulsion removal products: Traditional Systems 1, 2, 3 and 4, Alternative System Chi, and Alternative Ink remover Beta. Limited performance and/or cost information is available for Traditional Systems 1, 2, 3 and 4, and Alternative System Chi. Figure V-1 provides a schematic illustration of the product groups used in the two steps required under Method 1.

Traditional System 1

Formulation

Ink Remover: 100% Mineral spirits
Emulsion Remover: 12 wt% Sodium hypochlorite/ 88% water

Figure V - 1
Process Steps Included in Method 1



Occupational Exposure

Table V-1
Occupational Exposure Estimates for Method 1, Traditional System 1

	Inhalation (mg/day)				Dermal (mg/day)	
	I	II	III	IV	Routine	Immersion
Ink Remover						
Mineral spirits- light hydrotreated	26	0.1	0	0.3	1560	7280
Emulsion Remover						
Sodium hypochlorite	0	0	0	0	187	874
Water	0	0	0	0	1370	6410

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry.

Occupational Risk Estimates

Quantitative risk estimates could not be determined for this system due to insufficient data. See risk conclusions for areas of concern for this system.

Occupational Risk Conclusions and Observations

Ink Remover

- Dermal exposures to workers using mineral spirits in ink removal can be very high, although the risks from mineral spirits could not be quantified because of limitations in hazard data.

Emulsion Removers (All Systems)

- All of the systems that employ an emulsion remover use either a strong oxidizer such as hypochlorite or periodate or a strong base such as sodium hydroxide. The haze removers in Alpha, Epsilon, Gamma, Mu, Omicron, and Theta also contain these compounds. All of these materials present a high concern for skin and eye irritation and tissue damage if workers are exposed in the absence of proper protective clothing. None of the emulsion removers present significant inhalation risks.

Environmental Releases

Table V-2
Estimated Environmental Releases for Screen Cleaning Operations
Method 1, Traditional System 1

System	Release Under Each Scenario (g/day)						
	I			II	III	IV	
	Air	Water	Land	Air	Air	Air	Water
Ink Remover							
Mineral spirits- light hydrotreated	54	0	1050	0.2	0.1	0.6	1350
Emulsion Remover							
Sodium hypochlorite	0	75	0	0	0	0	0
Water	0	546	0	0	0	0	0

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry.

Table V-3
Summary of Estimated Daily Environmental Releases from a Hypothetical Facility
Using Screen Reclamation Method 1, Traditional System 1

Substance	To Air	To Water	To Landfill
Mineral Spirits	54.9 g/day	1350 g/day[a]	1050 g/day[a]
Sodium Hypochlorite		75 g/day	

[a]1,350 g/day is estimated to be released from the rags. This release from the rags will be either to landfill or to water. If the release is to water through the laundry (launderable rags), then the landfill column is blank. If the release is to landfill (disposable rags), then the landfill column will be 1,050 g/day. This is true of all of the ink remover chemicals. For our purposes, the rest of the assessment assumes release to water only, since we are not assessing landfill releases.

Releases to Water from a Single Facility

Table V-4
Estimated Releases to Water from Traditional Formulations from Screen Reclamation at a Single Facility
Screen Reclamation Method 1, Traditional System 1

Substance	Amount Released to Water from Facility	Waste water Treatment Removal Efficiency	Amount to Water After Waste Water Treatment	Daily Stream Concentration, ug/L[a] for 1000 MLD Receiving Water
Mineral Spirits	1350 g/day at laundry	94%	81 g/day	8×10^{-2}
Sodium Hypochlorite[b]	75 g/day	100 %	0	0

[a]ug/L is Micrograms per liter, which is parts per billion for a substance in water. MLD is Million liters per day.
[b]Concentrated solutions of sodium hypochlorite will kill the biota which degrade organic chemicals (the other substances listed in the table) during waste water treatment. This could cause problems at the waste water treatment plant, reducing the waste water treatment efficiency for the other compounds sent to the plant.

Releases to Water from Multiple Screen Printers

The concentrations listed in the chart above are relatively low. However, in the local area there may be many screen printers, all of which are connected to the same waste treatment facility. The concentration in the stream would be the combined amounts of all of the releases in the stream, which could be significant, even if the release from one screen printing facility is not.

To demonstrate the combined effects, the multiple screen printing facilities in St. Louis County, Missouri were picked as an example. The Dun and Bradstreet data shows 135 screen printing facilities in St. Louis County. We are assuming that the waste water from all of these is going to the St. Louis County Sewer Company, which releases into the Meramec River. Less than five kilometers downstream is the Kirkwood Water Department, and just about ten kilometers downstream is an intake for the St. Louis County Water company. These service an estimated 28 thousand people and one million people, respectively. The mean flow of the river is 7895 million liters per day (MLD), and is not any larger at the drinking water intakes than it is at the release point.

Table V-5
Estimated Cumulative Releases to Water for St. Louis County, MO
Screen Reclamation Method 1, Traditional System 1

Substance	Total Amount Released to Water from All Facilities	Waste Water Treatment Removal Efficiency	Amount to Water After Waste water Treatment	Average Concentration in Meramec River, ug/L (ppb)
Mineral Spirits	182 kg/day at laundry	94 %	11 kg/day	1
Sodium Hypochlorite	10 kg/day	100 %	0	0

Releases to Air from Individual Screen Printing Facilities

Table V-6
Air Release, Concentration and Potential Dose Estimates from a Single Model Facility
Screen Reclamation Method 1, Traditional System 1

Substance	Amount of Releases per day	Highest Average Concentration 100 M away	Annual Potential Dose, mg/year[a]
Mineral Spirits	54.9 g/day	1×10^{-1} ug/m^3	7×10^{-1}

[a]This estimates doses for people living 100 Meters from the hypothetical facility. The actual number of people who would fall into this range can be determined from census data, if the facility location is known. The model used to calculate concentrations is more completely explained in the Overview by Media-Air Section in Chapter III. To calculate the annual potential dose, the concentration is multiplied by the amount a person will breathe (20 m^3/day) and the number of days per year (365), and the units are converted to mg/year by dividing by 1000.

General Population Risk Conclusions and Observations

- Health risks to the general population from both air and water exposures are very low for Method 1, Traditional System 1.

Because of the low concentration estimate found from single source releases, multiple facility impacts are note likely to significantly raise concentration estimates. Examples of general population exposure and risk estimates are shown for Method 2, Traditional System 1 in Methods 1 and 2, and Alternative System Chi in Method 2; please reference these sections as illustrative examples. Hazard Quotient values below one indicate very low risk. Margin-of-Exposure (MOE) values above 100 for a NOAEL or above 1000 for a LOAEL indicate very low risk.

Ecological Risks From Water Releases Of Screen Reclamation Chemicals

- Cumulative releases of mineral spirits from Traditional System 1 present a concern for risk to aquatic species. The largest contributor to these releases is the hypothetical commercial laundry that launders the shop rags used by the area's screen printers.

- None of the other components of Method 1, Traditional System 1 reached an ecotoxicity concern concentration, even when considering the cumulative releases from all shops in the area.

- None of the single facility releases of Method 1, Traditional System 1 reach an ecotoxicity concern concentration.

The following table summarizes the exposure and risk estimates for cumulative releases of Traditional System 1. The analogous figures for single facilities show much lower exposure and risk levels.

Table V-7
Estimated Cumulative Releases to Water for St. Louis County, MO
Screen Reclamation Method 1, Traditional System 1

Substance	Total Amount Released to Water from All Facilities	Waste water Treatment Removal Efficiency	Amount to Water After Waste water Treatment	Daily Stream Conc. in Meramec River, ug/L (ppb)	ECO CC (ug/l)	ECO Risk Indicator (Stream Conc/ ECO CC)
Mineral Spirits	16 kg/day + 182 kg/day at laundry	94 %	960 g/day 11 kg/day	1×10^{-1} 1	1	1.1
Sodium Hypochlorite	10 kg/day	100 %	0	0	<20	0

Performance

The performance of this system was not demonstrated at the Screen Printing Technical Foundation or at volunteer printing facilities. Since this system is commonly used in many screen printing shops, it was decided to use the limited resources available for a performance demonstration to evaluate alternatives to the traditionally used product systems.

Cost

Because the performance of this system was not determined in this project, the total cost of using this system was also not calculated.

Traditional System 2

Formulation

Ink Remover: 100% Acetone
Emulsion Remover: 1% Sodium periodate/ 99% water

Occupational Exposure

Table V-8
Occupational Exposure Estimates for Method 1, Traditional System 2

System	Inhalation (mg/day)				Dermal (mg/day)	
	I	II	III	IV	Routine	Immersion
Ink Remover						
Acetone	539	11	5	38	1560	7280
Emulsion Remover (Zeta diluted 1:4)						
Sodium periodate	0	0	0	0	16	73
Water	0	0	0	0	1540	7210

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry.

Occupational Risk Conclusions and Observations

Ink Remover

- Hazard quotient calculations indicate clear concerns for chronic dermal and inhalation exposures to workers using acetone in either ink removal or haze removal.

Emulsion Removers (All Systems)

- All of the systems that employ an emulsion remover use either a strong oxidizer such as hypochlorite or periodate or a strong base such as sodium hydroxide. The haze removers in Alpha, Epsilon, Gamma, Mu, Omicron, and Theta also contain these compounds. All of these materials present a high concern for skin and eye irritation and tissue damage if workers are exposed in the absence of proper protective clothing. None of the emulsion removers present significant inhalation risks.

Table V-9
Occupational Risk Estimates for Method 1, Traditional System 2.

Name	Hazard Quotient[b]			Margin Of Exposure[a]					
		Dermal		Inhalation		Dermal			
						Routine		Immersion	
	Inhalation	Routine	Immersion	NOAEL[c]	LOAEL[d]	NOAEL	LOAEL	NOAEL	LOAEL
Ink Remover						NA	NA	NA	NA
Acetone	84	22	1,040	NA	NA	NA	NA	NA	NA
Emulsion Remover (Zeta diluted 1:4)									
Sodium periodate	NA	NA	NA	NA	NA	NA	NA	NA	NA
Water	NA	NA	NA	NA	NA	NA	NA	NA	NA

[a]Margin of Exposure (MOE) values above 100 for a NOAEL and 1000 for a LOAEL indicate low risk.
[b]Hazard Quotient is the ratio of the estimated chronic dose/exposure level to the Reference Dose (RfD) or the Reference Concentration (RfC). Hazard Quotient values less than 1 imply that adverse effects are very unlikely to occur.
[c]NOAEL means No Observed Adverse Effect Level.
[d]LOAEL means Lowest Observed Adverse Effect Level.

Environmental Releases

Table V-10
Estimated Environmental Releases in Screen Cleaning Operations
Method 1, Traditional System 2

System	Release Under Each Scenario (g/day)						
	I			II	III	IV	
	Air	Water	Land	Air	Air	Air	Water
Ink Remover							
Acetone	1120	0	0	22	11	80	1270
Emulsion Remover (Zeta diluted 1:4)							
Sodium periodate	0	6	0	0	0	0	0
Water	0	615	0	0	0	0	0

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry.

Table V-11
Summary of Estimated Daily Environmental Releases from a Hypothetical Facility
Using Method 1, Traditional System 2

Substance	To Air	To Water	To Landfill
Acetone	1,233 g/day	1,270[a] g/day	1,270[a] g/day
Sodium Periodate		6 g/day	

[a]1,270 g/day is estimated to be released from the rags. This release from the rags will be either to landfill or to water. If the release is to water through the laundry, then the landfill column is blank. If the release is to landfill, then the landfill column will be 1,270 g/day and the water column will be empty. This is true of all of the ink remover chemicals. For our purposes, the rest of the assessment assumes release to water only, since we are not assessing landfill releases.

Releases to Water from a Single Facility

Table V-12
Estimated Releases to Water from Method 1, Traditional System 2

Substance	Amount Released to Water from Facility	Waste Water Treatment Removal Efficiency	Amount to Water After Waste water Treatment	Daily Stream Concentration, ug/L[a] for 1,000 MLD Receiving Water
Acetone	1270 g/day	87%	165 g/day	0.2
Sodium Periodate	6 g/day	100%	0 g/day	0

[a]ug/L is Micrograms per liter, which is parts per billion for a substance in water. MLD is Million liters per day.

Releases to Water from Multiple Screen Printers

The concentrations listed in the chart above are relatively low. However, in the local area there may be many screen printers, all of which are connected to the same waste treatment facility. The concentration in the stream would be the combined amounts of all of the releases in the stream, which could be significant, even if the release from one screen printing facility is not.

To demonstrate the combined effects, the multiple screen printing facilities in St. Louis County, Missouri were picked as an example. The Dun and Bradstreet data shows 135 screen printing facilities in St. Louis County. We are assuming that the waste water from all of these is going to the St. Louis County Sewer Company, which releases into the Meramec River. Less than five kilometers downstream is the Kirkwood Water Department, and just about ten kilometers downstream is an intake for the St. Louis County Water company. These service an estimated 28 thousand people and one million people, respectively. The mean flow of the river is 7895 million liters per day (MLD), and is not any larger at the drinking water intakes than it is at the release point.

Table V-13
Estimated Cumulative Releases to Water for St. Louis County, MO
Method 1, Traditional System 2

Substance	Total Amount Released to Water from All Facilities	Waste water Treatment Removal Efficiency	Amount to Water After Waste water Treatment	Average Concentration in Meramec River, ug/L (ppb)
Acetone	171 kg/day	87%	22.3 kg/day	3
Sodium Periodate	810 g/day	>>99%	<< 8.1 g/day	<< 8×10^{-4}

[a]>> is very much greater than, << is very much less than.

Releases to Air from Individual Screen Printing Facilities

Table V-14
Air Release, Concentration and Potential Dose Estimates from a Single Model Facility
Method 1, Traditional System 2

Substance	Amount of Releases per day	Highest Average Concentration 100 M away	Annual Potential Dose, mg/year[a]
Acetone	1233 g/day	3 ug/m^3	20

[a]This estimates doses for people living 100 Meters from hypothetical facility. The actual number of people who would fall into this range can be determined from census data, if the facility location is known. The model is more completely explained in the Overview by Media-Air Section in Chapter III. To calculate the annual potential dose, the concentration is multiplied by the amount a person will breathe (20 m^3/day) and the number of days per year (365), and the units are converted to mg/year by dividing by 1000.

General Population Risk Conclusions and Observations

- Health risks to the general population from both air and water exposures are very low for Method 1, Traditional System 2.

Although air releases were evaluated for only a single facility, it is very unlikely that an analysis of cumulative air releases would lead to different risk conclusions. Examples of general population exposure and risk estimates are shown for Method 2, Traditional System 1 in Methods 1 and 2, and Alternative System Chi in Method 2; please reference these sections as illustrative examples. Hazard Quotient values below one indicate very low risk. Margin-of-Exposure (MOE) values above 100 for a NOAEL or above 1000 for a LOAEL indicate very low risk.

Ecological Risks From Water Releases Of Screen Reclamation Chemicals

- None of the components of Method 1, Traditional System 2 reached an ecotoxicity concern concentration, even when considering the cumulative releases from all shops in the area.

- None of the single facility releases of Method 1, Traditional System 2 reach an ecotoxicity concern concentration.

The following table summarizes the exposure and risk estimates for cumulative releases of Traditional System 2. The analogous figures for single facilities show much lower exposure and risk levels.

Table V-15
Estimated Cumulative Releases to Water for St. Louis County, MO
Screen Reclamation Method 2, Traditional System 2

Substance	Total Amount Released to Water from All Facilities	Waste water Treatment Removal Efficiency	Amount to Water After Waste water Treatment	Daily Stream Conc. in Meramec River, ug/L (ppb)	ECO CC (ug/L)	ECO RISK INDICATOR (STREAM CONC/ ECO CC)
Acetone	171 kg/day	87%	22.3 kg/day	3	7600	$4x10^{-4}$
Sodium Periodate	810 g/day	>>99%	<< 8.1 g/day	$<< 8 \times 10^{-4}$	<10	$\sim 10^{-5}$

Performance

The performance of this system was not demonstrated at the Screen Printing Technical Foundation or at volunteer printing facilities. Since this system is commonly used in many screen printing shops, it was decided to use the limited resources available for a performance demonstration to evaluate alternatives to the traditionally used product systems.

Cost

Because the performance of this system was not determined in this project, the total cost of using this system was also not calculated.

Traditional System 3

Formulation

Ink Remover: 100% Lacquer Thinner, consisting of:
30% Methyl ethyl ketone
15% n-butyl acetate
5% Methanol
20% Naphtha, light aliphatic
20% Toluene
10% Isobutyl isobutyrate

Emulsion Remover: 12 wt% Sodium hypochlorite, 88% water

Occupational Exposure

Table V-16
Occupational Exposure Estimates for Method 1, Traditional System 3

System	Inhalation (mg/day)				Dermal (mg/day)	
	I	II	III	IV	Routine	Immersion
Ink Remover						
Methyl ethyl ketone(2-butanone)	165	5.3	3	20	468	2180
Butyl acetate normal	44	1.3	1	5.3	234	1090
Methanol	27	4.7	2	15	78	364
Naphtha, light aliphatic	98	1.6	1	6.2	312	1460
Toluene	110	2.3	1	9.2	312	1460
Isobutyl isobutyrate	7	0.4	0	1.7	156	728
Emulsion Remover (Bleach)						
Sodium hypochlorite	0	0	0	0	187	874
Water	0	0	0	0	1370	874

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry.

Occupational Risk Conclusions and Observations

Ink Remover

- Hazard quotient calculations indicate clear concerns for both toluene and methyl ethyl ketone with respect to chronic dermal and inhalation exposures to workers using these chemicals in ink removal.

Table V-17
Occupational Risk Estimates for Method 2, Traditional System 3.

Name	Hazard Quotient[b]			Margin Of Exposure[a]					
				Inhalation		Dermal			
		Dermal				Routine		Immersion	
	Inhalation	Routine	Immersion	NOAEL[c]	LOAEL[d]	NOAEL	LOAEL	NOAEL	LOAEL
Ink Remover									
Methyl ethyl ketone (2-butanone)	9.2	22	103	NA	NA	NA	NA	NA	NA
Butyl acetate normal	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methanol	1.4	2.2	10	NA	NA	NA	NA	NA	NA
Aromatic solvent naphtha	NA	NA	NA	NA	NA	NA	NA	NA	NA
Toluene	17.	44.	208.	NA	NA	NA	NA	NA	NA
Isobutyl isobutyrate	NA	NA	NA	NA	NA	NA	NA	NA	NA
Emulsion Remover (Bleach)									
Sodium hypochlorite	NA	NA	NA	NA	NA	NA	NA	NA	NA
Water	NA	NA	NA	NA	NA	NA	NA	NA	NA

[a]Margin of Exposure (MOE) values above 100 for a NOAEL and 1000 for a LOAEL indicate low risk.
[b]Hazard Quotient is the ratio of the estimated chronic dose/exposure level to the Reference Dose (RfD) or the Reference Concentration (RfC). Hazard Quotient values less than 1 imply that adverse effects are very unlikely to occur.
[c]NOAEL means No Observed Adverse Effect Level.
[d]LOAEL means Lowest Observed Adverse Effect Level.

- Hazard quotient calculations indicate marginal concerns for chronic inhalation exposure to workers using methanol in ink removal.

Emulsion Removers (All Systems)

- All of the systems that employ an emulsion remover use either a strong oxidizer such as hypochlorite or periodate or a strong base such as sodium hydroxide. The haze removers in Alpha, Epsilon, Gamma, Mu, Omicron, and Theta also contain these compounds. All of these materials present a high concern for skin and eye irritation and tissue damage if workers are exposed in the absence of proper protective clothing. None of the emulsion removers present significant inhalation risks.

Environmental Releases

Table V-18
Estimated Environmental Releases in Screen Cleaning Operations
Method 1, Traditional System 3

System	Release Under Each Scenario (g/day)						
	I			II	III	IV	
	air	water	land	air	air	air	water
Ink Remover							
Methyl ethyl ketone(2-butanone)	344	0	0	11	5.7	42	363
Butyl acetate normal	92	0	80	2.6	1.5	11	191
Methanol	57	0	0	9.8	4.1	30	37
Naphtha, light aliphatic	204	0	25	3.2	1.7	13	257
Toluene	229	0	0	4.8	2.6	19	251
Isobutyl isobutyrate	15	0	100	0.8	0.5	3.4	132
Emulsion Remover (Bleach)							
Sodium hypochlorite	0	75	0	0	0	0	0
Water	0	546	0	0	0	0	0

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry.

Table V-19
Summary of Estimated Daily Environmental Releases from a Hypothetical Facility Using Method 1, Traditional System 3

Substance:	To Air:	To Water:	To Landfill:
Methyl ethyl ketone	403 g/day	363 g/day at laundry	
n-butyl Acetate	107 g/day	191 g/day at laundry[a]	80 g/day[a]
Methanol	101 g/day	37 g/day at laundry	
Naphtha, light aliphatic	222 g/day	257 g/day at laundry	25 g/day
Toluene	255 g/day	251 g/day at laundry	
Isobutyl isobutyrate	19.7 g/day	132 g/day at laundry	100 g/day
Sodium hypochlorite		75 g/day	

[a]The landfill number is the amount estimated to be released from the rags. This release from the rags will be either to landfill or to water. If the release is to water through the laundry, then the landfill column is blank. This is true of all of the ink remover chemicals. For our purposes, the rest of the assessment assumes release to water only, since we are not assessing landfill releases.

Releases to Water from a Single Facility

Table V-20
Estimated Releases to Water from Traditional Formulations from Screen Reclamation at a Single Facility
Method 1, Traditional System 3

Substance	Amount Released to Water from Facility	Waste water Treatment Removal Efficiency	Amount to Water After Waste water Treatment	Mean Daily Concentration, ug/L[a] for 1000 MLD Receiving Water
Methyl Ethyl Ketone	363 g/day at laundry	84%	58 g/day	6×10^{-2}
n-butyl acetate	191 g/day at laundry	97%	5.7 g/day	6×10^{-3}
Methanol	37 g/day at laundry	97%	1.1 g/day	1×10^{-3}
Naphtha, light aliphatic	257 g/day at laundry	94%	15 g/day	2×10^{-2}
Toluene	251 g/day at laundry	92%	20 g/day	2×10^{-2}
Isobutyl isobutyrate	132 g/day at laundry	98%	2.6 g/day	3×10^{-3}
Sodium Hypochlorite[b]	75 g/day	100 %	0	0

[a]ug/L is Micrograms per liter, which is parts per billion for a substance in water. MLD is Million liters per day.
[b]Concentrated solutions of sodium hypochlorite will kill the biota which degrade organic chemicals (the other substances listed in the table) during waste water treatment. This could cause problems at the waste water treatment plant, reducing the waste water treatment efficiency for the other compounds sent to the plant.

Releases to Water from Multiple Screen Printers

The concentrations listed in the chart above are relatively low. However, in the local area there may be many screen printers, all of which are connected to the same waste treatment facility. The concentration in the stream would be the combined amounts of all of the releases in the stream, which could be significant, even if the release from one screen printing facility is not.

To demonstrate the combined effects, the multiple screen printing facilities in St. Louis County, Missouri were picked as an example. The Dun and Bradstreet data shows 135 screen printing facilities in St. Louis County. We are assuming that the waste water from all of these is going to the St. Louis County Sewer Company, which releases into the Meramec River. Less than five kilometers downstream is the Kirkwood Water Department, and just about ten kilometers downstream is an intake for the St. Louis County Water company. These service an estimated 28 thousand people and one million people, respectively. The mean flow of the river is 7895 million liters per day (MLD), and is not any larger at the drinking water intakes than it is at the release point.

Table V-21
Estimated Cumulative Releases to Water for St. Louis County, MO
Method 1, Traditional System 3

Substance	Total Amount Released to Water from All Facilities	Waste water Treatment Removal Efficiency	Amount to Water After Waste water Treatment	Average Concentration in Meramec River, ug/L (ppb)
Methyl ethyl ketone	49 kg/day	84%	7.8 kg/day	1
n-butyl acetate	26 kg/day	97%	8×10^{-1} kg/day	1×10^{-1}
Methanol	5 kg/day	97%	150 g/day	2×10^{-2}
Naphtha, light aliphatic	35 kg/day	94%	2.1 kg/day	3×10^{-1}
Toluene	34 kg/day	92%	2.7 kg/day	3×10^{-1}
Isobutyl isobutyrate	18 kg/day	98%	360 g/day	4×10^{-2}
Sodium Hypochlorite	10 kg/day	>> 99%	<<100 g/day	$<<1 \times 10^{-2}$

Releases to Air from Individual Screen Printing Facilities

Table V-22
Air Release, Concentration and Potential Dose Estimates from a Single Model Facility
Method 1, Traditional System 3

Substance	Amount of Releases per day	Highest Average Concentration 100 M away	Annual Potential Dose, mg/year[a]
Methyl Ethyl Ketone	403 g/day	8×10^{-1} ug/m^3	6
n-butyl acetate	107 g/day	2×10^{-1} ug/m^3	1
Methanol	101 g/day	2×10^{-1} ug/m^3	1
Naphtha, light aliphatic	222 g/day	4×10^{-1} ug/m^3	3
Toluene	255 g/day	5×10^{-1} ug/m^3	4
Isobutyl isobutyrate	19.7	4×10^{-2} ug/m^3	0.3

[a]This estimates doses for people living 100 Meters from hypothetical facility. The actual number of people who would fall into this range can be determined from census data, if the facility location is known. The model is more completely explained in the Overview by Media-Air Section in Chapter III. To calculate the annual potential dose, the concentration is multiplied by the amount a person will breathe (20 m^3/day) and the number of days per year (365), and the units are converted to mg/year by dividing by 1000.

General Population Risk Conclusions and Observations

- Health risks to the general population from both air and water exposures are estimated to be very low for Method 1, Traditional System 3.

Although air releases were evaluated for only a single facility, it is very unlikely that an analysis of cumulative air releases would lead to different risk conclusions. Examples of general population exposure and risk estimates are shown for Method 2, Traditional System 1. Hazard Quotient values below one indicate very low risk. Margin-of-Exposure (MOE) values above 100 for a NOAEL or above 1000 for a LOAEL indicate very low risk.

Table V-23
Risks from Potential Drinking Water Exposures
Screen Reclamation Method 1, Traditional System 3

Substance	Daily Stream Concentration in Meramec River, ug/L (ppb)	Daily dose from Drinking Water (mg/kg)	RfD (mg/kg)	Hazard Quotient (dose/RfD)
Methyl ethyl ketone	1	$3x10^{-5}$	0.6	$5x10^{-5}$
n-butyl acetate	1×10^{-1}	$3x10^{-6}$	not available	
Methanol	2×10^{-2}	$6x10^{-7}$	0.5	$1x10^{-6}$
Naphtha, light aliphatic	3×10^{-1}	$9x10^{-6}$	not available	
Toluene	3×10^{-1}	$9x10^{-6}$	0.2	$4x10^{-5}$
Isobutyl isobutyrate	4×10^{-2}	$1x10^{-6}$	not available	
Sodium Hypochlorite	$<<1 \times 10^{-2}$	$<<3x10^{-7}$	not available	

Table V-24
Estimated Risks from Ambient Air Releases from a Single Model Facility
Screen Reclamation Method 1, Traditional System 3

Substance	Highest Avg Concentration 100 M away	Daily Potential Dose, (mg/kg)	RfD/RfC (mg/kg, mg/m_3)	Hazard Quotient(dose or conc/RfDor RfC)
Methyl Ethyl Ketone	8×10^{-1} ug/m^3	$2x10^{-4}$	1 mg/m^3	$8x10^{-4}$
n-butyl acetate	2×10^{-1} ug/m^3	$4x10^{-5}$	not available	
Methanol	2×10^{-1} ug/m^3	$4x10^{-5}$	0.5 mg/kg	$8x10^{-5}$
Naphtha,light aliphatic	4×10^{-1} ug/m^3	$1x10^{-4}$	not available	
Toluene	5×10^{-1} ug/m^3	$2x10^{-4}$	0.4 mg/m^3	$1x10^{-3}$
Isobutyl isobutyrate	4×10^{-2} ug/m^3	$1x10^{-5}$	not available	

Ecological Risks From Water Releases Of Screen Reclamation Chemicals

- None of the components of Method 1, Traditional System 3 reached an ecotoxicity concern concentration, even when considering the cumulative releases from all shops in the area.

- None of the single facility releases of Method 1, Traditional System 3 reach an ecotoxicity concern concentration.

The following table summarizes the exposure and risk estimates for cumulative releases of Traditional System 3. The analogous figures for single facilities show much lower exposure and risk levels.

Table V-25
Estimated Cumulative Releases to Water for St. Louis County, MO
Screen Reclamation Method 1, Traditional System 3

Substance	Total Amount Released to Water from All Facilities	Waste water Treatment Removal Efficiency	Amount to Water After Waste water Treatment	Daily Stream Conc. in Meramec River, ug/L (ppb)	ECO CC (ug/L)	ECO RISK INDICATOR (STREAM CONC/ ECO CC)
Methyl ethyl ketone	49 kg/day	84%	7.8 kg/day	1	4500	$2x10^{-4}$
n-butyl acetate	26 kg/day	97%	8×10^{-1} kg/day	1×10^{-1}	140	$7x10^{-4}$
Methanol	5 kg/day	97%	150 g/day	2×10^{-2}	9000	$2x10^{-6}$
Naphtha, light aliphatic	35 kg/day	94%	2.1 kg/day	3×10^{-1}	5	0.06
Toluene	34 kg/day	92%	2.7 kg/day	3×10^{-1}	110	$3x10^{-3}$
Isobutyl isobutyrate	18 kg/day	98%	360 g/day	4×10^{-2}	80	$5x10^{-4}$
Sodium Hypochlorite	10 kg/day	>> 99%	<<100 g/day	$<<1 \times 10^{-2}$	<20	~0.05

Performance

The performance of a similar system was demonstrated at the Screen Printing Technical Foundation; the performance demonstration differed from this product system in that it included the use of a haze remover containing potassium hydroxide and tetrahydrofurfuryl alcohol. Reference Traditional System 3 in Method 2 for a complete description of the performance of this system with a haze remover.

Cost

Because the performance of this particular system was not determined in this project, the total cost of using this system was not determined.

Traditional System 4

Formulation

Ink Remover: 100% Lacquer Thinner, consisting of:
30% Methyl ethyl ketone
15% n-butyl acetate
5% Methanol
20% Naphtha, light aliphatic
20% Toluene
10% Isobutyl isobutyrate

Emulsion Remover: 1% Sodium periodate, 99% water

Occupational Exposure

Table V-26
Occupational Exposure Estimates for Method 1, Traditional System 4

System	Inhalation (mg/day)				Dermal (mg/day)	
	I	II	III	IV	Routine	Immersion
Ink Remover						
Methyl ethyl ketone(2-butanone)	165	5.3	3	20	468	2180
Butyl acetate normal	44	1.3	1	5.3	234	1090
Methanol	27	4.7	2	15	78	364
Naphtha, light aliphatic	98	1.6	1	6.2	312	1460
Toluene	110	2.3	1	9.2	312	1460
Isobutyl isobutyrate	7	0.4	0	1.7	156	728
Emulsion Remover (Zeta diluted 1:4)						
Sodium periodate	0	0	0	0	16	73
Water	0	0	0	0	1540	7210

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry.

Occupational Risk Conclusions and Observations

Ink Remover

- Hazard quotient calculations indicate clear concerns for both toluene and methyl ethyl ketone with respect to chronic dermal and inhalation exposures to workers using these chemicals in ink removal.

Table V-27
Occupational Risk Estimates for Method 1, Traditional System 4

Name	Hazard Quotient[b]			Margin Of Exposure[a]					
		Dermal		Inhalation		Dermal			
						Routine		Immersion	
	Inhalation	Routine	Immersion	NOAEL[c]	LOAEL[d]	NOAEL	LOAEL	NOAEL	LOAEL
Ink Remover									
Methyl ethyl ketone (2-butanone)	9.29	22	103	NA	NA	NA	NA	NA	NA
Butyl acetate normal	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methanol	1.4	2.2	10.4	NA	NA	NA	NA	NA	NA
Aromatic solvent naphtha	NA	NA	NA	NA	NA	NA	NA	NA	NA
Toluene	17	46	210	NA	NA	NA	NA	NA	NA
Isobutyl isobutyrate	NA	NA	NA	NA	NA	NA	NA	NA	NA
Emulsion Remover (Zeta diluted 1:4)									
Sodium periodate	NA	NA	NA	NA	NA	NA	NA	NA	NA
Water	NA	NA	NA	NA	NA	NA	NA	NA	NA

[a]Margin of Exposure (MOE) values above 100 for a NOAEL and 1000 for a LOAEL indicate low risk.
[b]Hazard Quotient is the ratio of the estimated chronic dose/exposure level to the Reference Dose (RfD) or the Reference Concentration (RfC). Hazard Quotient values less than 1 imply that adverse effects are very unlikely to occur.
[c]NOAEL means No Observed Adverse Effect Level.
[d]LOAEL means Lowest Observed Adverse Effect Level.

- Hazard quotient calculations indicate marginal concerns for chronic inhalation exposure to workers using methanol in ink removal.

Emulsion Removers (All Systems)

- All of the systems that employ an emulsion remover use either a strong oxidizer such as hypochlorite or periodate or a strong base such as sodium hydroxide. The haze removers in Alpha, Epsilon, Gamma, Mu, Omicron, and Theta also contain these compounds. All of these materials present a high concern for skin and eye irritation and tissue damage if workers are exposed in the absence of proper protective clothing. None of the emulsion removers present significant inhalation risks.

Environmental Releases

Table V-28
Estimated Environmental Releases in Screen Cleaning Operations
Method 1, Traditional System 4

System	Release Under Each Scenario (g/day)						
	I			II	III	IV	
	air	water	land	air	air	air	water
Ink Remover							
Methyl ethyl ketone(2-butanone)	344	0	0	11	5.7	42	363
Butyl acetate normal	92	0	80	2.6	1.5	11	191
Methanol	57	0	0	9.8	4.1	30	37
Naphtha, light aliphatic	204	0	25	3.2	1.7	13	257
Toluene	229	0	0	4.8	2.6	19	251
Isobutyl isobutyrate	15	0	100	0.8	0.5	3.4	132
Emulsion Remover (Zeta diluted 1:4)							
Sodium periodate	0	6	0	0	0	0	0
Water	0	615	0	0	0	0	0

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry.

Table V-29
Summary of Estimated Daily Environmental Releases from a Hypothetical Facility Using Method 1, Traditional System 4

Substance:	To Air:	To Water:	To Landfill:
Methyl ethyl ketone	403 g/day	363 g/day at laundry	
n-butyl Acetate	107 g/day	191 g/day at laundry[a]	80 g/day[a]
Methanol	101 g/day	37 g/day at laundry	
Naphtha, light aliphatic	222 g/day	257 g/day at laundry	25 g/day
Toluene	255 g/day	251 g/day at laundry	
Isobutyl isobutyrate	19.7 g/day	132 g/day at laundry	100 g/day
Sodium periodate		6 g/day	

[a]191 g/day is estimated to be released from the rags if the rags are laundered. This release from the rags will be either to landfill or to water. If the release is to water through the laundry, then the landfill column is blank. If the release is to landfill, then the landfill column will be 80 g/day and the water column will be blank. This is true for all of the ink remover chemicals. For our purposes, the rest of the assessment assumes release to water only, since we are not assessing landfill releases.

Releases to Water from a Single Facility

Table V-30
Estimated Releases to Water from Traditional Formulations from Screen Reclamation at a Single Facility
Method 1, Traditional System 4

Substance	Amount Released to Water from Facility	Waste water Treatment Removal Efficiency	Amount to Water After Waste Water Treatment	Daily Stream Concentration, ug/L[a] for 1000 MLD Receiving Water
Methyl Ethyl Ketone	363 g/day at laundry	84%	58 g/day	6×10^{-2}
n-butyl acetate	191 g/day at laundry	97%	5.7 g/day	6×10^{-3}
Methanol	37 g/day at laundry	97%	1.1 g/day	1×10^{-3}
Naphtha, light aliphatic	257 g/day at laundry	94%	15.4 g/day	2×10^{-2}
Toluene	251 g/day at laundry	92%	20 g/day	2×10^{-2}
Isobutyl isobutyrate	132 g/day at laundry	98%	2.6 g/day	3×10^{-3}
Sodium periodate	6 g/day	100 %	0	0

[a]ug/L is Micrograms per liter, which is parts per billion for a substance in water. MLD is Million liters per day.

Releases to Water from Multiple Screen Printers

The concentrations listed in the chart above are relatively low. However, in the local area there may be many screen printers, all of which are connected to the same waste treatment facility. The concentration in the stream would be the combined amounts of all of the releases in the stream, which could be significant, even if the release from one screen printing facility is not.

To demonstrate the combined effects, the multiple screen printing facilities in St. Louis County, Missouri were picked as an example. The Dun and Bradstreet data shows 135 screen printing facilities in St. Louis County. We are assuming that the waste water from all of these is going to the St. Louis County Sewer Company, which releases into the Meramec River. Less than five kilometers downstream is the Kirkwood Water Department, and just about ten kilometers downstream is an intake for the St. Louis County Water company. These service an estimated 28 thousand people and one million people, respectively. The mean flow of the river is 7895 million liters per day (MLD), and is not any larger at the drinking water intakes than it is at the release point.

Table V-31
Estimated Cumulative Releases to Water for St. Louis County, MO
Method 1, Traditional System 4

Substance	Total Amount Released to Water from All Facilities	Waste water Treatment Removal Efficiency	Amount to Water After Waste water Treatment	Average Concentration in Meramec River, ug/L (ppb)
Methyl ethyl ketone	49 kg/day	84%	7.8 kg/day	1
n-butyl acetate	26 kg/day	97%	0.8 kg/day	1×10^{-1}
Methanol	5 kg/day	97%	150 g/day	2×10^{-2}
Naphtha, light aliphatic	35 kg/day	94%	2.1 kg/day	3×10^{-1}
Toluene	34 kg/day	92%	2.7 kg/day	3×10^{-1}
Isobutyl isobutyrate	18 kg/day	98%	360 g/day	4×10^{-2}
Sodium Periodate	810 g/day	>> 99%	<< 8.1 g/day	$<<1 \times 10^{-3}$

These stream concentrations will be put into perspective in the risk integration section of this document. Please refer to that section for information on how to interpret these concentrations.

Releases to Air from Individual Screen Printing Facilities

Table V-32
Air Release, Concentration and Potential Dose Estimates for a Single Model Facility
Method 1, Traditional System 4

Substance	Amount of Releases per day	Highest Average Concentration 100 M away	Annual Potential Dose, mg/year[a]
Methyl Ethyl Ketone	403 g/day	8×10^{-1} ug/m^3	6
n-butyl acetate	107 g/day	2×10^{-1} ug/m^3	1
Methanol	101 g/day	2×10^{-1} ug/m^3	1
Naphtha, light aliphatic	222 g/day	4×10^{-1} ug/m^3	3
Toluene	255 g/day	5×10^{-1} ug/m^3	4
Isobutyl isobutyrate	19.7	4×10^{-2} ug/m^3	3×10^{-1}

[a]This estimates doses for people living 100 Meters from hypothetical facility. The actual number of people who would fall into this range can be determined from census data, if the facility location is known. The model is more completely explained in the Overview by Media-Air Section in Chapter III. To calculate the annual potential dose, the concentration is multiplied by the amount a person will breathe (20 m^3/day) and the number of days per year (365), and the units are converted to mg/year by dividing by 1000.

General Population Risk Conclusions and Observations

- Health risks to the general population from both air and water exposures are very low for Method 1, Traditional System 4.

Although air releases were evaluated for only a single facility, it is very unlikely that an analysis of cumulative air releases would lead to different risk conclusions. Examples of general population exposure and risk estimates are shown for Method 2, Traditional System 1 in Methods 1 and 2, and Alternative System Chi in Method 2; please reference these sections as illustrative examples. Hazard Quotient values below one indicate very low risk. Margin-of-Exposure (MOE) values above 100 for a NOAEL or above 1000 for a LOAEL indicate very low risk.

Ecological Risks From Water Releases Of Screen Reclamation Chemicals

- None of the components of Method 1, Traditional System 4 reached an ecotoxicity concern concentration, even when considering the cumulative releases from all shops in the area.

- None of the single facility releases of Method 1, Traditional System 4 reach an ecotoxicity concern concentration.

The following table summarizes the exposure and risk estimates for cumulative releases of Traditional System 4. The analogous figures for single facilities show much lower exposure and risk levels.

Table V-33
Estimated Cumulative Releases for St. Louis County, MO
Screen Reclamation Method 1, Traditional System 4

Substance	Total Amount Released to Water from All Facilities	Waste water Treatment Removal Efficiency	Amount to Water After Waste water Treatment	Daily Stream Conc. in Meramec River, ug/L (ppb)	ECO CC (ug/L)	ECO RISK INDICATOR (STREAM CONC/ ECO CC)
Methyl ethyl ketone	49 kg/day	84%	7.8 kg/day	1	4500	$2x10^{-4}$
n-butyl acetate	26 kg/day	97%	0.8 kg/day	1×10^{-1}	140	$7x10^{-4}$
Methanol	5 kg/day	97%	150 g/day	2×10^{-2}	9000	$2x10^{-6}$
Naphtha, light aliphatic	35 kg/day	94%	2.1 kg/day	3×10^{-1}	5	0.06
Toluene	34 kg/day	92%	2.7 kg/day	3×10^{-1}	110	$3x10^{-3}$
Isobutyl isobutyrate	18 kg/day	98%	360 g/day	4×10^{-2}	80	$5x10^{-4}$
Sodium Periodate	810 g/day	>> 99%	<< 8.1 g/day	$<<1 \times 10^{-3}$	<10	$\sim 10^{-4}$

Performance

The performance of this system was not demonstrated at the Screen Printing Technical Foundation or at volunteer printing facilities. Since this system is commonly used in many screen printing shops, it was decided to use the limited resources available for a performance demonstration to evaluate alternatives to the traditionally used product systems.

Cost

Table V-34
Method 1: Summary of Cost Analysis for Baseline
(Traditional System 4 Minus Haze Remover)

Cost Element Description		Traditional System 4 (minus Haze Remover)
Facility Characteristics		
Average screen size (in^2)		2,127
Average # screens/day		6
Cost Elements per Screen		
Labor	Time spent applying, scrubbing, and removing reclamation products (min)	12.9
	Cost ($)	2.82
Materials and Equipment	# of rags used	3
	Cost ($)	0.45
Reclamation Product Use	Ink Remover	
	Average Volume (oz.)	8.0
	Cost ($)	0.22
	Emulsion Remover	
	Average Volume (oz.)	3.5
	Cost ($)	0.13
	Haze Remover	
	Average Volume (oz.)	---
	Cost ($)	---
Hazardous Waste Disposal	Amount (g)	34
	Cost ($)	0.02
Totals		
Total Cost($/Screen)		3.63
Total Cost($/year)		5,446

Alternative System Chi

Formulation

Ink Remover:	Diethylene glycol series ethers
	Propylene glycol series ethers
	N-methyl pyrrolidone
	Ethoxylated nonylphenol
Emulsion Remover:	Sodium periodate
	Water

Occupational Exposure

Table V-35
Occupational Exposure Estimates for Method 1, Alternative System Chi

System	Inhalation (mg/day)				Dermal (mg/day)	
	I	II	III	IV	Routine	Immersion
Ink Remover						
Diethylene glycol series ethers	0	0	0	0	312	1456
Tripropylene glycol methyl ether	0	0	0	0	858	4000
N-methylpyrrolidone	3	0	0	0.1	312	1460
Ethoxylated nonylphenol	0	0	0	0	78	364
Emulsion Remover (diluted 1:4)						
Sodium periodate	0	0	0	0	16	73
Water	0	0	0	0	1540	7210

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry.

Occupational Risk Conclusions and Observations

Ink Remover

- Clear concerns exist for chronic dermal exposures to the diethylene glycol series ethers used in ink removal based on the calculated margins-of-exposure.
- Concerns exist for developmental toxicity risks from dermal exposures to N-methylpyrrolidone based on the calculated margin-of-exposure. Similar calculations for inhalation exposures to N-methylpyrrolidone indicate very low concern.

Table V-36
Occupational Risk Estimates for Method 1, System CHI

Name	Hazard Quotient[b]			Margin Of Exposure[a]					
		Dermal		Inhalation		Dermal			
						Routine		Immersion	
	Inhalation	Routine	Immersion	NOAEL[c]	LOAEL[d]	NOAEL	LOAEL	NOAEL	LOAEL
Ink Remover									
Diethylene glycol series ethers	NA	NA	NA	NA	NA	1,800	46	380	9.8
Tripropylene glycol series ethers	NA	NA	NA	NA	NA	NA	NA	NA	NA
N-methylpyrrolidone	NA	NA	NA	3,600	NA	39	NA	8.4	NA
Ethoxylated nonylphenol	NA	NA	NA	NA	NA	NA	NA	NA	NA
Emulsion Remover (diluted 1:4)									
Sodium periodate	NA	NA	NA	NA	NA	NA	NA	NA	NA
Water	NA	NA	NA	NA	NA	NA	NA	NA	NA

[a]Margin of Exposure (MOE) values above 100 for a NOAEL and 1000 for a LOAEL indicate low risk.
[b]Hazard Quotient is the ratio of the estimated chronic dose/exposure level to the Reference Dose (RfD) or the Reference Concentration (RfC). Hazard Quotient values less than 1 imply that adverse effects are very unlikely to occur.
[c]NOAEL means No Observed Adverse Effect Level.
[d]LOAEL means Lowest Observed Adverse Effect Level.

- Inhalation exposures to other ink remover components are very low.

- Dermal risks from other ink remover components could not be quantified because of limitations in hazard data, but exposures can be high.

Emulsion Removers (All Systems)

- All of the systems that employ an emulsion remover use either a strong oxidizer such as hypochlorite or periodate or a strong base such as sodium hydroxide. The haze removers in Alpha, Epsilon, Gamma, Mu, Omicron, and Theta also contain these compounds. All of these materials present a high concern for skin and eye irritation and tissue damage if workers are exposed in the absence of proper protective clothing. None of the emulsion removers present significant inhalation risks.

Environmental Releases

Table V-37
Estimated Environmental Releases in Screen Cleaning Operations
Method 1, Alternative System Chi

System	Release Under Each Scenario (g/day)						
	I			II	III	IV	
	air	water	land	air	air	air	water
Ink Remover							
Diethylene glycol series ethers	0.1	0	138	0	0	0	270
Tripropylene glycol series ethers	0.1	0	381	0	0	0	742
N-methylpyrrolidone	6.8	0	132	0.1	0	0.2	270
Ethoxylated nonylphenol	0	0	35	0	0	0	67
Emulsion Remover (diluted 1:4)							
Sodium periodate	0	6	0	0	0	0	0
Water	0	615	0	0	0	0	0

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry.

Table V-38
Summary of Estimated Daily Environmental Releases from a Hypothetical Facility Using Screen Reclamation Method 1, Alternative System Chi

Substance:	To Air:	To Water:	To Landfill:
Diethylene glycol series ethers	0.1 g/day	270 g/day at laundry	138 g/day
Propylene glycol series ethers	0.1 g/day	742 g/day at laundry	381 g/day
N-methyl pyrrolidone	7.1 g/day	270 g/day at laundry	132 g/day
Ethoxylated nonylphenol		67 g/day at laundry	35 g/day
Sodium Periodate		6 g/day	

Releases to Water from a Single Facility

Table V-39
Estimated Releases to Water from Traditional Formulations from Screen Reclamation at a Single Facility Using Screen Reclamation Method 1, Alternative System Chi

Substance	Amount Released to Water from Facility	Waste water Treatment Removal Efficiency	Amount to Water After Waste water Treatment	Daily Stream Concentration, ug/L[a] for 1000 MLD Receiving Water
Diethylene glycol series ethers	270 g/day at laundry	83%	46 g/day	4×10^{-2}
Propylene glycol series ethers	742 g/day at laundry	83-97%	126 g/day	1×10^{-1}
N-methyl pyrrolidone	270 g/day at laundry	97%	8.1 g/day	8×10^{-3}
Ethoxylated nonylphenol	67 g/day at laundry	100%	0 g/day	0
Sodium periodate	6 g/day	>>99%	<<.06 g/day	$<< 6 \times 10^{-5}$

[a]ug/L is Micrograms per liter, which is parts per billion for a substance in water. MLD is Million liters per day.

Releases to Air from Individual Screen Printing Facilities

Table V-40
Air Release, Concentration and Potential Dose Estimates from a Single Model Facility Using Screen Reclamation Method 1, Alternative System Chi

Substance	Amount of Releases per day	Highest Average Concentration 100 M away	Annual Potential Dose, mg/year[a]
Diethylene glycol series ethers	0.1 g/day	2×10^{-4} ug/m^3	1×10^{-3}
Propylene glycol series ethers	0.1 g/day	2×10^{-4} ug/m^3	1×10^{-3}
N-methyl pyrrolidone	7.1 g/day	1×10^{-2} ug/m^3	1×10^{-1}

[a]This estimates doses for people living 100 Meters from hypothetical facility. The actual number of people who would fall into this range can be determined from census data, if the facility location is known. The model is more completely explained in the Overview by Media-Air Section in Chapter III. To calculate the annual potential dose, the concentration is multiplied by the amount a person will breathe (20 m^3/day) and the number of days per year (365), and the units are converted to mg/year by dividing by 1000.

General Population Risk Conclusions and Observations

- Health risks to the general population from both air and water exposures are very low for Method 2, Alternative System Chi.

Although air releases were evaluated for only a single facility, it is very unlikely that an analysis of cumulative air releases would lead to different risk conclusions. Examples of general population exposure and risk estimates are shown for Alternative System Chi in Method 2. Hazard Quotient values below one indicate very low risk. Margin-of-Exposure (MOE) values above 100 for a NOAEL or above 1000 for a LOAEL indicate very low risk.

Ecological Risks From Water Releases Of Screen Reclamation Chemicals

- None of the single facility releases of Method 1, Alternative System Chi reach an ecotoxicity concern concentration.

Performance

The performance of System Chi, with the ink remover also in use as a haze remover, was demonstrated at the Screen Printing Technical Foundation and at two volunteer printing facilities. Reference Product System Chi in Method 2 for details of these performance evaluations. The information reported from Facility 21 will be particularly applicable to Method 1 as Facility 21 was able to use the ink remover/emulsion remover combination and achieve acceptable performance. Facility 21 noted that all screens could be reused for future jobs and that this system worked particularly well in removing metallic inks.

Cost

Table V-41
Method 1: Summary of Cost Analysis for Method 1, Alternative System Chi

Cost Element Description		Baseline (Traditional System 4-Haze Remover)	Alternative System Chi	
			Facility 3	Facility 21
Facility Characteristics				
Average screen size (in^2)		2,127	1,977	1,088
Average # screens/day		6	15	23
Cost Elements per Screen				
Labor	Time spent applying, scrubbing, and removing reclamation products (min)	12.9	9.4	4.5
	Cost ($)	2.82	2.07	0.98
Materials and Equipment	# of rags used	3	1.2	1.2
	Cost ($)	0.45	0.18	0.19
Reclamation Product Use	Ink Remover Average Volume (oz.)	8.0	1.1	1.1
	Cost ($)	0.22	0.21	0.21
	Emulsion Remover Average Volume (oz.)	3.5	2.1	1.5
	Cost ($)	0.13	0.07	0.05
	Haze Remover Average Volume (oz.)	---	---	---
	Cost ($)	---	---	---
Hazardous Waste Disposal	Amount (g)	34	0	0
	Cost ($)	0.02	0	0
Totals				
Total Cost ($/screen)		3.63	2.53	1.43
Normalized[a]		3.63	2.83	1.95
Total Cost ($/year)		5,466	9,497	8,005
Normalized[a]		5,446	4,245	2,918

[a]Normalized values adjust product usage, number of screens cleaned, and number of rags laundered at demonstration facilities to reflect the screen size and number of screens cleaned per day under the baseline scenario. Labor costs, however, are not normalized. Normalization allows a comparison between the baseline and facility results.

Note: For additional information regarding product performance see performance demonstration summaries.

Alternative System Beta

Unlike other manufacturers who participated in the project, this manufacturer submitted only an ink remover, rather than a product system consisting of ink remover, emulsion remover and haze remover. To accommodate the screen reclamation methods identified in this CTSA and develop a risk assessment based on a product system, an emulsion remover product was arbitrarily added to ink remover Beta to form Product System Beta. While the risk and cost assessment include this other product, the performance of the ink remover was profiled at a single facility (12) which used their standard emulsion and haze remover to completely clean their screens. Due to a lack of information about the standard emulsion and haze remover products used by Facility 12, the risk assessment for these products was not undertaken.

Formulation

Ink Remover: 2-octadecanamine, N, N-dimethyl-, N-oxide or a modified amine from unsaturated soy bean oil fatty acid/ water

Emulsion Remover: Sodium periodate
Water

Occupational Exposure

Table V-42
Occupational Exposure Estimates for Method 1, Alternative Beta

System	Inhalation (mg/day)				Dermal (mg/day)	
	I	II	III	IV	Routine	Immersion
Ink Remover						
2-Octadecanamine, N,N-dimethyl, N-oxide	292	4.3	3	0	1530	7130
Water	0	0	0	0	31	146
Emulsion Remover (diluted 1:4)						
Sodium periodate	0	6	0	0	0	0
Water	0	615	0	0	0	0

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry.

Occupational Risk Estimates

Quantitative risk estimates could not be determined for this system due to insufficient data. See risk conclusions for areas of concern for this system.

Occupational Risk Conclusions and Observations

Ink Remover

- Both inhalation and dermal exposures to workers using 2-octadecanamine, N,N-dimethyl-, N-oxide in ink removal can be high, although the risks could not be quantified because of limitations in hazard data.

Emulsion Removers (All Systems)

- All of the systems that employ an emulsion remover use either a strong oxidizer such as hypochlorite or periodate or a strong base such as sodium hydroxide. The haze removers in Alpha, Epsilon, Gamma, Mu, Omicron, and Theta also contain these compounds. All of these materials present a high concern for skin and eye irritation and tissue damage if workers are exposed in the absence of proper protective clothing. None of the emulsion removers present significant inhalation risks.

Environmental Releases

Table V-43
Estimated Environmental Releases in Screen Cleaning Operations
Method 1, Alternative System Beta

System	Release Under Each Scenario (g/day)						
	I			II	III	IV	
	air	water	land	air	air	air	water
Ink Remover							
2-Octadecanamine, N,N-dimethyl, N-oxide	609	0	0	9.1	6.3	0	0
Water	0	0	12	0	0	0	0
Emulsion Remover (Zeta diluted 1:4)							
Sodium periodate	0	6	0	0	0	0	0
Water	0	615	0	0	0	0	0

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry.

Table V-44
Summary of Estimated Daily Environmental Releases from a Hypothetical Facility Using Screen Reclamation Method 1, Alternative System Beta

Substance:	To Air:	To Water:	To Landfill:
2-octadecanamine, N,N-dimethyl, N-oxide	624 g/day		
Sodium periodate		5 g/day	

Releases to Water from a Single Facility

Table V-45
Estimated Releases to Water from Traditional Formulations from Screen Reclamation at a Single Facility Using Screen Reclamation Method 1, Alternative System Beta

Substance	Amount Released to Water from Facility	Waste water Treatment Removal Efficiency	Amount to Water After Waste water Treatment	Daily Stream Concentration, ug/L[a] for 1000 MLD Receiving Water
Sodium periodate	5 g/day	100 %	0	0

[a]ug/L is Micrograms per liter, which is parts per billion for a substance in water. MLD is Million liters per day.

Releases to Air from Individual Screen Printing Facilities

Table V-46
Air Releases, Concentrations and Potential Dose Estimates from a Single Model Facility Using Screen Reclamation Method 1, Alternative System Beta

Substance	Amount of Releases per day	Highest Average Concentration 100 M away	Annual Potential Dose, mg/year[a]
2-Octadecanamine, N,N-dimethyl, N-oxide	624 g/day	1.3 ug/m^3	9

[a]This estimates doses for people living 100 Meters from the hypothetical facility. The actual number of people who would fall into this range can be determined from census data, if the facility location is known. The model used to calculate concentrations is more completely explained in the Overview by Media-Air Section in Chapter III. To calculate the annual potential dose, the concentration is multiplied by the amount a person will breathe (20 m^3/day) and the number of days per year (365), and the units are converted to mg/year by dividing by 1000.

General Population Risk Conclusions and Observations

- Health risks to the general population from both air and water exposures are very low for Method 1, Alternative System Beta.

Although air releases were evaluated for only a single facility, it is very unlikely that an analysis of cumulative air releases would lead to different risk conclusions. Examples of general population exposure and risk estimates are shown for Method 2, Traditional System 1 in Methods 1 and 2, and Alternative System Chi in Method 2; please reference these sections as illustrative examples. Hazard Quotient values below one indicate very low risk. Margin-of-Exposure (MOE) values above 100 for a NOAEL or above 1000 for a LOAEL indicate very low risk.

Ecological Risks From Water Releases Of Screen Reclamation Chemicals

- None of the single facility releases of Method 1, Alternative System Beta reach an ecotoxicity concern concentration.

Performance

General Summary of Ink Remover Beta Performance, and Related Variables

Facility 12 used ink remover Beta during the performance demonstrations. Unlike the Product Systems submitted by other manufacturers, the manufacturer of Beta supplied the ink remover only. The facility used the alternative ink remover Beta, along with their standard emulsion remover and haze remover to reclaim their screens. During the demonstrations, the performance of ink remover Beta was recorded for 17 screens with solvent-based inks over a three week period. Facility 12 prints graphic overlays, labels, and flexible membrane switches, and all products are primarily printed on plastics.

Ink remover Beta was also sent to two other facilities who were not able to participate in the Performance Demonstrations. One facility could not use the product because they send all their screens out to be reclaimed; they only use ink removers as an in-process cleaner. Since this project is intended to evaluate ink removers used for screen reclamation, not for in-process ink removal, this facility did not participate. The second facility felt they could not use the alternative system because of an on-going EPA inspection. The printer regretted not being able to participate, however, the EPA was in the process of testing his waste water, so he did not want to add any new chemicals to his waste stream.

Facility 12 reported that the ink remover removed the ink on most screens, but it also left an oily residue on the screen. Prior to the demonstration, this facility used an acetone and toluene blend that left no residue on the screen. The printer found that the ink wiped off more easily when it was wet, however it was very time-consuming to remove dried ink. On some screens, it took 30 minutes to remove the ink.

Alternative Ink Remover Beta Profile

The manufacturer recommends applying ink remover Beta as follows:

Water Resistant Emulsions: Card off the excess ink from the screen. Using a spray bottle, apply the ink remover to the screen. After a short penetration time (only for dried inks) use high pressure water and rinse all the ink residue from the screen. For tests done at SPTF, a 1000 psi spray was used for rinsing the ink remover.

Non Water Resistant Emulsions: Card off the excess ink from the screen. Using a spray bottle, spray the ink remover directly onto the screen. Clean the screen with a cloth slightly dampened with ink remover. Dry both sides of the screen with a dry and absorbent cloth.

Alternative System Performance at SPTF

Ink remover Beta was tested at SPTF on three screens (one with a solvent-based ink, one with a UV-curable ink, and one with a water-based ink). On all three screens, the technician reported that the ink dissolved well, however a fair amount of wiping was required. For the screen with the solvent-based ink, seven wipes were needed. Six wipes were used on the UV ink screen, and eight wipes were required to remove the ink from the water-based ink screen. On all three screens, the technician noticed that the ink remover affected the stencil image in the half tone area. The color of the stencil appeared on the rag, which also indicated that the product was deteriorating the emulsion.

Alternative System Performance Details

Performance Details from Facility 12

Facility 12 felt the ink remover Beta sufficiently removed the ink from most screens, however, it took a long time to remove the ink and the product left an oily haze on the screen. In some cases, they reported ink residue or ink stains were also left in the mesh. The oily film and the ink residue were both removed during emulsion removal and haze removal steps, and all screens were reusable for all types of printing jobs.

Unlike all of the other facilities in the Performance Demonstrations, an observer did not visit this facility to introduce them to the project and to the alternative system. This lack of in-person guidance may have affected the results. During the first week, the printer sprayed on the ink remover, rubbed it in with a brush and pressure washed the screen to remove the ink. This application method was very messy and did not effectively remove the ink. For the remainder of the demonstrations, the printer changed his application method and used rags to wipe the ink off the screen. This second method removed the ink much more easily, but took a long time (an average of 25 minutes per screen). Two or three rags were used on each screen. While wiping the screen with the rags, the printer noticed that the emulsion started to deteriorate. He also mentioned that he needed to replace his filters on the ink removal sink waste water more frequently when using the alternative system.

In reviewing the data, there did not appear to be any correlations between the product performance and the screen conditions, however, the printer felt it was much easier to remove wet ink and light colored inks, than dried on and black ink.

Alternative System Performance Table Compiled from Field Sites

The following table highlights the observed performance of the ink remover and the relevant conditions at the demonstration facility. In addition to the field demonstrations data, results of the product tests performed at SPTF are also summarized in this table.

Table V-47
Performance Summary for Ink Remover BETA

	System Component	Performance						Demonstration Conditions			
		Avg Drying Time Before Using Product	Average Quantity Applied	Average Cleaning Time	Average Effort Required	Performance for Each System Component	Overall System Performance	Ink type(s)	Emulsion type	Mesh type; Thread count	Average Screen Size
In-field Demonstrations at Volunteer Printing Facilities											
Facility 12	*Ink remover*	3.9 ± 8.2 hrs (n=15)	4.2 ± 1.5 oz. (n=17)	24.6 ± 5.4 mins (n=17)	Moderate	Removed ink but took a long time and left an oily residue.	• Not demonstrated as part of a system.	Solvent-based ink	Capillary film	Polyester, abraded; 195 - 390 threads/ inch	1089 in^2
Laboratory Testing at SPTF											
SPTF Solvent-based Ink	*Ink Remover*	15 mins	2.5 oz.	9.1 mins	Moderate	Ink dissolved well, but 7 rags were needed and the stencil started to deteriorate.		Solvent-based	Dual cure direct	Polyester; 260 threads/ inch	360 in^2
SPTF UV-curable Ink	*Ink Remover*	15 mins	2.5 oz.	6.3 mins	Moderate	Ink dissolved well, but 6 rags were needed and the stencil started to deteriorate.		UV-curable	Dual cure direct	Polyester; 390 threads/ inch	360 in^2
SPTF Water-based Ink	*Ink Remover*	15 mins	3.0 oz.	12.0 mins	Moderate	Ink dissolved well, but it took a long time (8 rags were needed) and the stencil started to deteriorate.		Water-based	Dual cure direct	Polyester; 260 threads/ inch	360 in^2

Facility Profiles

General Facility Background for Facility 12

Facility 12 prints graphic overlays, labels, and flexible membrane switches on plastics, paper, and metals. Their typical run length is one hour, and approximately 70% of their orders are repeat orders. There are about 10 employees involved in screen printing at this location, and approximately 4 are involved in screen reclamation. Solvent-based vinyl and polyester inks used at this facility. Screens with mesh counts of 195 - 390 threads/inch and capillary film emulsions were used during the demonstrations. The average screen size at this facility is 9 ft^2 and 10 - 15 screens are reclaimed daily.

Screen Reclamation Area in Facility 12

Ink removal is done in a spray booth where a local, mechanical system provides ventilation. Screen reclamation is done in a high-pressure (2700 psi) water blaster booth. Waste water from the wash of the emulsion remover and haze remover is filtered prior to discharge to the sewer. Filters and spent solvent from the ink removal area are disposed of as hazardous waste.

Current Screen Reclamation Products at Facility 12

This facility uses a solvent blend ink remover containing 50% toluene and 50% acetone. Their emulsion remover consists primarily of sodium periodate. For haze removal, they use a proprietary solvent blend which includes sodium hydroxide and cyclohexanone.

Current Screen Reclamation Practices in Facility 12

Using their standard products, this facility reclaims their screens following the procedure described below. Personal protective equipment worn by operators includes gloves, eye protection, respiratory protection, and rubber boots (for haze removal).

- Ink Remover: Card off the excess ink. Spray the ink remover onto the screen from a low pressure tank (60 psi). Wipe off the dissolved ink with disposable rags (one or two rags are used on each screen).

- Emulsion Remover: Spray the emulsion remover onto both sides of the screen. Brush the emulsion remover into the screen. Pressure rinse and allow to air dry.

- Haze Remover: Dip a brush into the container of haze remover and rub it into the screen. Rinse with the high-pressure water blaster.

Cost

Table V-48
Method 1: Summary of Cost Analysis for Alternative Beta

Description		Baseline (Traditional System 4 minus Haze Remover)	Alternative System Beta[a] Facility 12
Facility Characteristics			
Average screen size (in^2)		2,127	1,089
Average # screens/day		6	15
Cost Elements per Screen			
Labor	Time spent applying, scrubbing, and removing reclamation products (min)	12.9	29.4
	Cost ($)	2.82	6.43
Materials and Equipment	# of rags used	3	2.2
	Cost ($)	0.45	0.34
Reclamation Product Use	Ink Remover		
	Average Volume (oz.)	8.0	4.2
	Cost ($)	0.22	0.50
	Emulsion Remover		
	Average Volume (oz.)	3.5	1.8
	Cost ($)	0.13	0.06
	Haze Remover		
	Average Volume (oz.)	---	---
	Cost ($)	---	---
Hazardous Waste Disposal	Amount (g)	34	0
	Cost ($)	0.02	0
Total Costs			
Total Cost ($/screen)		3.63	17.33
Normalized[b]		3.63	7.97
Total Cost ($/year)		5,446	27,477
Normalized[b]		5,446	11,958

[a]The emulsion removal use and cost per screen were taken from performance demonstration results for product system Zeta.

[b]Normalized values adjust product usage, number of screens cleaned, and number of rags laundered at demonstration facilities to reflect the screen size and number of screens cleaned per day under the baseline scenario. Labor costs, however, are not normalized. Normalization allows a comparison between the baseline and facility results.

Note: For additional information regarding product performance see performance demonstration summaries.

Method 2: Traditional Reclamation With Haze Remover

In a typical screen printing facility, ink remover, emulsion remover and haze remover are all used in the process of screen reclamation. Method 2 incorporates the most common practices in screen reclamation; it differs from Method 1 in that printers are assumed to use a haze remover (see Figure V-2). For the purposes of determining occupational exposure to the haze remover, it was assumed that screen reclaimers only used haze remover on 1-2 screens of the estimated six screens reclaimed daily in the average small/medium screen printing facility.

Because Method 2 is most representative of current screen reclamation practices, the majority of alternative systems are included in this category. A total of fourteen systems are assessed, including four traditional systems and ten alternative systems. The alternative systems were submitted by manufacturers who volunteered to participate in the project. These systems were named Alpha, Chi, Delta, Epsilon, Gamma, Mu, Phi, Omicron-AE, Omicron-AF and Zeta. Printers who are interested in further exploration of the merits of one of these systems should contact the manufacturers listed in the acknowledgements section of the document.

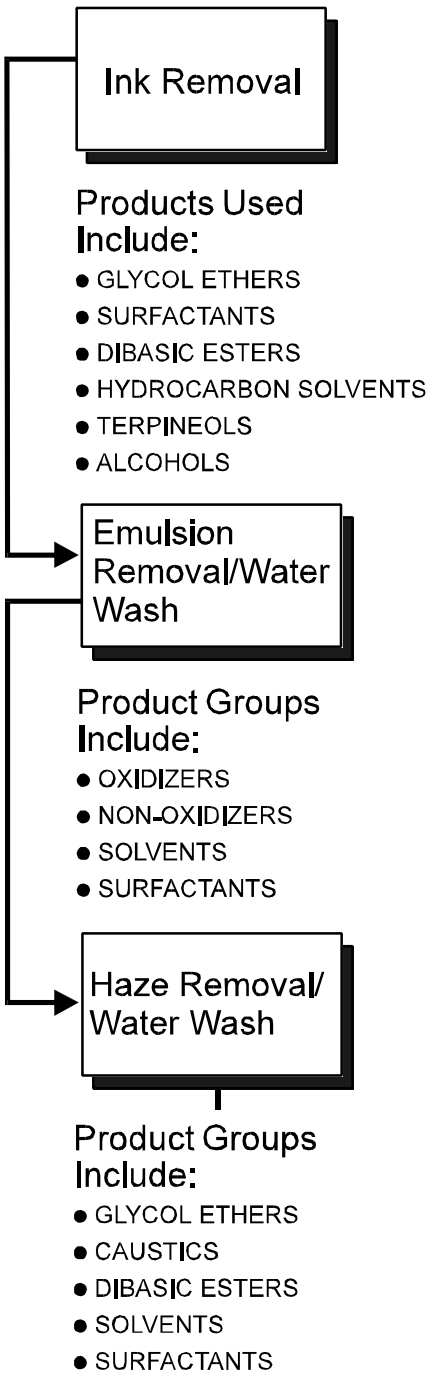
Although three chemical products are used in Method 2, as opposed to two chemical products in Method 1, pollution prevention can still be achieved through a combination of improved workplace practices and equipment modifications. Chapter 6 should be referenced to best determine which pollution prevention practices are most appropriate for a particular facility. In Chapter 6, a discussion of workplace practices reported by printers as a means of reducing or preventing pollution is followed by an overview of spray applicator systems, washout booths, filtration systems, recirculation systems and distillation units. All of these modifications can be used in combination with Method 2 to prevent pollution.

Traditional System 1

Formulation

Ink Remover:	100% Mineral spirits
Emulsion Remover:	12% Sodium hypochlorite (bleach)
Haze Remover:	10% Xylene
	30% Acetone
	30% Mineral spirits
	30% Cyclohexanone

Figure V - 2
Process Steps Included in Method 2



Occupational Exposure

Table V-49
Occupational Exposure Estimates For Method 2, Traditional System 1

System	Inhalation Exposures, by Scenario (mg/day)				Dermal Exposures, (mg/day)	
	I	II	III	IV	Routine	Immersion
Ink Remover						
Mineral spirits- light hydrotreated	26	0.1	0	0.3	1560	7280
Emulsion Remover						
Sodium hypochlorite	0	0	0	0	187	874
Water	0	0	0	0	1370	6410
Haze Remover						
Xylenes (mixed)	21	0.9	1	0	156	728
Acetone	64	11	5	0	468	2180
Mineral spirits-light hydrotreated	7	0.1	0	0	468	2180
Cyclohexanone	27	0.3	0	0	468	2180

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry

Occupational Risk Conclusions and Observations

Ink Remover and Haze Remover

- Hazard quotient calculations indicate clear concerns for chronic dermal and inhalation exposures to workers using acetone in haze removal.
- Hazard quotient calculations indicate marginal concerns for chronic dermal exposures to workers using xylene and cyclohexanone in haze removal.
- Margin-of-exposure calculations indicate very low concern for developmental and reproductive toxicity risks from inhalation of cyclohexanone. Reproductive and developmental toxicity risks from dermal exposures to cyclohexanone could not be quantified.
- Dermal exposures to workers using mineral spirits in ink removal can be very high, although the risks from mineral spirits could not be quantified because of limitations in hazard data.

Emulsion Removers (All Systems)

- All of the systems that employ an emulsion remover use either a strong oxidizer such as hypochlorite or periodate or a strong base such as sodium hydroxide.

Table V-50
Occupational Risk Estimates for Method 2, Traditional System 1

Name	Hazard Quotient			Margin Of Exposure[a]					
		Dermal		Inhalation		Dermal			
						Routine		Immersion	
	Inhalation	Routine	Immersion	NOAEL[b]	LOAEL[c]	NOAEL	LOAEL	NOAEL	LOAEL
Ink Remover									
Mineral spirits- light hydrotreated	NA	NA	NA	NA	NA	NA	NA	NA	NA
Emulsion Remover									
Sodium hypochlorite		NA	NA	NA	NA	NA	NA	NA	NA
Water	NA	NA	NA	NA	NA	NA	NA	NA	NA
Haze Remover									
Xylenes (mixed isomers)	0.2	1.1	5.2	NA	NA	NA	NA	NA	NA
Acetone	11	66	311	NA	NA	NA	NA	NA	NA
Mineral spirits- light hydrotreated	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cyclohexanone	0.08	1.3	6.2	180	NA	NA	NA	NA	NA

[a]NA means Not Available.
[b]NOAEL means No Observed Adverse Effect Level.
[c]LOAEL means Lowest Observed Adverse Effect Level.

The haze removers in Alpha, Epsilon, Gamma, Mu, Omicron, and Theta also contain these compounds. All of these materials present a high concern for skin and eye irritation and tissue damage if workers are exposed in the absence of proper protective clothing. None of the emulsion removers present significant inhalation risks.

Environmental Releases

Table V-51
Estimated Environmental Releases in Screen Cleaning Operations
Method 2, Traditional System 1

System	Release Under Each Scenario (g/day)						
	I			II	III	IV	
	air	water	land	air	air	air	water
Ink Remover							
Mineral spirits- light hydrotreated	54	0	1050	0.2	0.1	0.6	1350
Emulsion Remover							
Sodium hypochlorite	0	75	0	0	0	0	0
Water	0	546	0	0	0	0	0
Haze Remover							
Xylenes (mixed isomers)	44	0	0	1.9	1.1	0	0
Acetone	133	0	0	22	11	0	0
Mineral spirits- light hydrotreated	15	119	0	0.2	0.1	0	0
Cyclohexanone	57	76	0	0.7	0.4	0	0

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry

Table V-52
Summary of Estimated Daily Environmental Releases from a Hypothetical Facility: Traditional System 1

Substance	To Air	To Water	To Landfill
Mineral Spirits	69.5 g/day	119 g/day 1350 g/day[a]	1053 g/day[a]
Sodium Hypochlorite		74.5 g/day	
Acetone	167 g/day		
Xylene	47.5 g/day		
Cyclohexanone	58.1 g/day	76.5 g/day	

[a]This release is either to water from the printing facility, or is sent with wastes to a waste handler to go to a landfill or to incineration. For our purposes, the rest of the assessment assumes release to water only, since we are not assessing landfill releases.

Releases to Water from a Single Facility

Table V-53
Estimated Releases to Water from Screen Reclamation at a Single Facility Traditional System 1

Substance	Amount Released to Water from Facility	Waste water Treatment Removal Efficiency	Amount to Water After Waste water Treatment	Daily Stream Concentration, ug/L[a] for 1000 MLD Receiving Water
Mineral Spirits	119 g/day 1350 g/day at laundry	99%	1.2 g/day 13.50 g/day	1.2×10^{-3}
Xylenes		75%		
Cyclohexanone	76.5 g/day	90%	7.6 g/day	7.6×10^{-3}
Sodium Hypochlorite[b]	74.5 g/day	>>[c] 99%	<< .7 g/day	<< 7×10^{-4}

[a]ug/L is Micrograms per liter, which is parts per billion for a substance in water. MLD is Million liters per day.
[b]Concentrated solutions of sodium hypochlorite will kill the biota which degrade organic chemicals (the other substances listed in the table) during waste water treatment. This could cause problems at the waste water treatment plant, reducing the waste water treatment efficiency for the other compounds sent to the plant.
[c]>> is very much greater than, << is very much less than.

Releases to Water from Multiple Screen Printers

The concentrations listed in the chart above are relatively low. However, in the local area there may be many screen printers, all of which are connected to the same waste treatment facility. The concentration in the stream would be the combined amounts of all of the releases in the stream, which could be significant, even though the release from one screen printing facility is not.

To demonstrate the combined effects, the multiple screen printing facilities in St. Louis County, Missouri were picked as an example. The Dun and Bradstreet data shows 135 screen printing facilities in St. Louis County. We are assuming that the waste water from all of these is going to the St. Louis County Sewer Company, which releases into the Meramec River. Less than five kilometers downstream is the Kirkwood Water Department, and just about ten kilometers downstream is an intake for the St. Louis County Water company. These service an estimated 28 thousand people and one million people, respectively. The mean flow of the river is 7895 million liters per day (MLD), and is not any larger at the drinking water intakes as it is at the release point.

Table V-54
Estimated Cumulative Releases for St. Louis County, MO
Traditional System 1

Substance	Total Amount Released to Water from All Facilities	Waste water Treatment Removal Efficiency	Amount to Water After Waste water Treatment	Daily Stream Concentration in Meramec River, ug/L (ppb)
Mineral Spirits	16 kg/day + 182 kg/day at laundry	99%	160 g/day 1.8 kg/day	1.6×10^{-1} 1.8
Cyclohexanone	10 kg/day	90%	1 g/day	1×10^{-3}
Sodium Hypochlorite	10 kg/day	>> 99%	<<100 g/day	<<1×10^{-1}

Releases to Air from Individual Screen Printing Facilities

Table V-55
Air Release, Concentration and Potential Dose Estimates From a Single Model Facility
Traditional System 1

Substance	Amount of Releases per day	Highest Average Concentration 100 M away	Annual Potential Dose, mg/year[a]
Mineral Spirits	69.5 g/day	3×10^{-1} ug/m^3	1.1
Acetone	167 g/day	23 ug/m^3	2.6
Xylene	47.5 g/day	9×10^{-2} ug/m^3	0.7
Cyclohexanone	58.1 g/day	1×10^{-1} ug/m^3	0.9

[a]This estimates doses for people living 100 Meters from the hypothetical facility. The actual number of people who would fall into this range can be determined from census data, if the facility location is known. The model used to calculate concentrations is more completely explained in the Overview by Media-Air Section in Chapter III. To calculate the annual potential dose, the concentration is multiplied by the amount a person will breathe (20 m^3/day) and the number of days per year (365), and the units are converted to mg/year by dividing by 1000.

The following graphic depicts the population near San Bernardino, CA, and the lines (isopleths) are equal average concentration of acetone from a hypothetical facility at 34° latitude and 117° longitude. The concentrations do not vary in concentric circles from the release point, but in patterns which depend on the weather and terrain.

Table V-56
Population Risk Estimates for Traditional System 1

Chemical Name	Ambient Air (Health)	Ambient Water (Health)	Ambient Water Conc/Eco CC
Mineral spirits	See note 1	See note 1	2
Sodium hypochlorite	Air releases not expected	See note 2	~ 10^{-3}
Xylene	Hazard Quotient = ~ 10^{-5}	Water releases not expected	Water releases not expected
Acetone	Hazard Quotient = ~ 10^{-3}	Water releases not expected	Water releases not expected
Cyclohexanone	Hazard Quotient = ~ 10^{-5}	Hazard Quotient = ~ 10^{-8}	~10^{-7}

Note 1: Risks resulting from exposures to mineral spirits could not be quantified.
Note 2: Human health risks from the release of hypochlorite to water are expected to be very low, but cannot be quantified because of limitations in the available hazard data. Estimated concentrations of hypochlorite in ambient water are much lower than hypochlorite concentrations in typical drinking water supplies.

General Population Risk Conclusions and Observations

- Health risks to the general population from both air and water exposures are very low for Method 2, Traditional System 1.

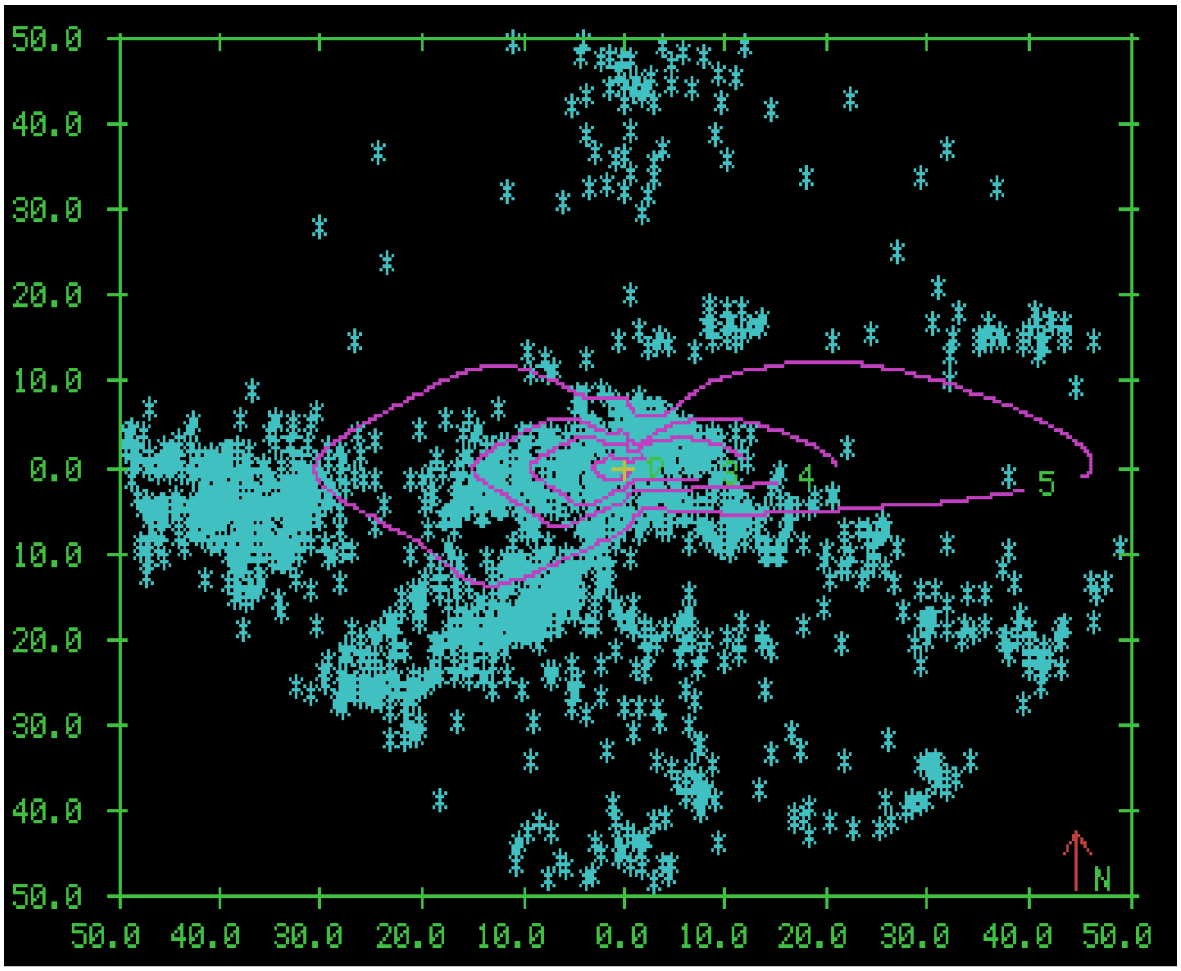
- Risks to the general population from ambient air and drinking water exposures are very low for Method 2, Traditional System 1.

- The major health impact on the general population for this type of product is probably its release of volatile organic compounds that contribute to the formation of photochemical smog in the ambient air.

- A marginal concern exists for risks to aquatic species resulting from the release of mineral spirits from a commercial laundry that launders shop rags from all of the screen printing facilities in the area. Aquatic risks from all of the chemicals are low with respect to direct water releases from the screen printing facilities.

Although air releases were evaluated for only a single facility, it is very unlikely that an analysis of cumulative air releases would lead to different risk conclusions. Examples of general population exposure and risk estimates are shown for Method 2, Traditional System 1 in Methods 1 and 2 and Alternative System Chi in Method 2; please reference these sections as illustrative examples. Hazard Quotient values below one indicate very low risk. Margin-of-Exposure (MOE) values above 100 for a NOAEL or above 1000 for a LOAEL indicate very low risk.

Figure V-3
Acetone Concentration Patterns Around a "Typical" Screen Print Facility



ISOPLETH #	CONCENTRATION, ug/m^3
1	5.4×10^{-4}
2	5.0×10^{-4}
3	1.0×10^{-4}
4	5.0×10^{-5}
5	1.8×10^{-5}

* = Population Centroid - Weighted center of population of one census block group. There are roughly 800 to 1200 people represented by each centroid.

Distances are in kilometers

Ecological Risks From Water Releases Of Screen Reclamation Chemicals

- Cumulative releases of mineral spirits from Traditional System 1 present a concern for risk to aquatic species. The largest contributor to these releases is the hypothetical commercial laundry that launders the shop rags used by the area's screen printers.

- None of the components of Method 2, Traditional System 1 reached an ecotoxicity concern concentration, even when considering the cumulative releases from all shops in the area.

- None of the single facility releases of Method 2, Traditional System 1 reach an ecotoxicity concern concentration.

The following table summarizes the exposure and risk estimates for cumulative releases of Traditional System 1. The analogous figures for single facilities show much lower exposure and risk levels.

Table V-57
Estimated Cumulative Releases for St. Louis County, MO
Screen Reclamation Method 2, Traditional System 1

Substance	Total Amount Released to Water from All Facilities	Waste water Treatment Removal Efficiency	Amount to Water After Waste water Treatment	Daily Stream Conc. in Meramec River, ug/L (ppb)	ECO CC (ug/l)	ECO RISK INDICATOR (STREAM CONC/ ECO CC)
Mineral Spirits	16 kg/day + 182 kg/day at laundry	94 %	960 g/day 11 kg/day	1×10^{-1} 1	1	1.1
Cyclohexanone	10 kg/day	83%	1.7 kg/day	2×10^{-1}	2800	7×10^{-5}
Sodium Hypochlorite	10 kg/day	100 %	0	0	<20	0

Performance

The performance of this system was not demonstrated at the Screen Printing Technical Foundation or at volunteer printing facilities. Since this system is commonly used in many screen printing shops, it was decided to use the limited resources available for a performance demonstration to evaluate alternatives to the traditionally used product systems.

Cost

Because the performance of this system was not determined in this project, the total cost of using this system was also not calculated.

Traditional System 2

Formulation

Ink Remover	100% Acetone
Emulsion Remover	12% Sodium hypochlorite (bleach)
Haze Remover	10% Xylene
	30% Acetone
	30% Mineral spirits
	30% Cyclohexanone

Occupational Exposure

Table V-58
Occupational Exposure Estimates for Method 2, Traditional System 2

System	Inhalation (mg/day)				Dermal (mg/day)	
	I	II	III	IV	Routine	Immersion
Ink Remover						
Acetone	539	11	5	38	1560	7280
Emulsion Remover (Bleach)						
Sodium hypochlorite	0	0	0	0	187	874
Water	0	0	0	0	1370	6410
Haze Remover						
Xylenes (mixed isomers)	21	0.9	1	0	156	728
Acetone	64	11	5	0	468	2180
Mineral spirits- light hydrotreated	7	0.1	0	0	468	2180
Cyclohexanone	27	0.3	0	0	468	2180

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry.

Table V-59
Occupational Risk Estimates for Method 2, Traditional System 2

Name	Hazard Quotient[b]			Margin Of Exposure[a]					
		Dermal		Inhalation		Dermal			
						Routine		Immersion	
	Inhalation	Routine	Immersion	NOAEL[c]	LOAEL[d]	NOAEL	LOAEL	NOAEL	LOAEL
Ink Remover									
Acetone	84	23	1,040	NA	NA	NA	NA	NA	NA
Emulsion Remover (Bleach)									
Sodium hypochlorite	NA	NA	NA	NA	NA	NA	NA	NA	NA
Water	NA	NA	NA	NA	NA	NA	NA	NA	NA
Haze Remover									
Xylenes (mixed isomers)	0.2	1.1	5.2	NA	NA	NA	NA	NA	NA
Acetone	11	66	311.	NA	NA	NA	NA	NA	NA
Mineral spirits- light hydrotreated	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cyclohexanone	0.07	1.3	6.2	180	NA	NA	0	0	0

[a]Margin of Exposure (MOE) values above 100 for a NOAEL and 1000 for a LOAEL indicate low risk.
[b]Hazard Quotient is the ratio of the estimated chronic dose/exposure level to the Reference Dose (RfD) or the Reference Concentration (RfC). Hazard Quotient values less than 1 imply that adverse effects are very unlikely to occur.
[c]NOAEL means No Observed Adverse Effect Level.
[d]LOAEL means Lowest Observed Adverse Effect Level.

Occupational Risk Conclusions and Observations

Ink Remover and Haze Remover

- Hazard quotient calculations indicate clear concerns for chronic dermal and inhalation exposures to workers using acetone in either ink removal or haze removal.

- Hazard quotient calculations indicate marginal concerns for dermal exposures to workers using xylene and cyclohexanone in haze removal.

- Margin-of-exposure calculations indicate very low concern for developmental and reproductive toxicity risks from inhalation of cyclohexanone. Reproductive and developmental toxicity risks from dermal exposures to cyclohexanone could not be quantified.

- Dermal exposures to workers using mineral spirits in haze removal can be high, although the risks from mineral spirits could not be quantified because of limitations in hazard data.

Emulsion Removers (All Systems)

- All of the systems that employ an emulsion remover (all systems except Beta) use either a strong oxidizer such as hypochlorite or periodate or a strong base such as sodium hydroxide. The haze removers in Alpha, Epsilon, Gamma, Mu, Omicron, and Theta also contain these compounds. All of these materials present a high concern for skin and eye irritation and tissue damage if workers are exposed in the absence of proper protective clothing. None of the emulsion removers present significant inhalation risks.

Environmental Releases

Table V-60
Estimated Environmental Releases in Screen Cleaning Operations
Method 2, Traditional System 2

System	Release Under Each Scenario (g/day)						
	I			II	III	IV	
	air	water	land	air	air	air	water
Ink Remover							
Acetone	1120	0	0	22	11	80	1270
Emulsion Remover (Bleach)							
Sodium hypochlorite	0	75	0	0	0	0	0
Water	0	546	0	0	0	0	0
Haze Remover							
Xylenes (mixed isomers)	44	0	0	1.9	1.1	0	0
Acetone	133	0	0	22	11	0	0
Mineral spirits- light hydrotreated	15	119	0	0.2	0.1	0	0
Cyclohexanone	57	76	0	0.7	0.4	0	0

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry.

Estimated Environmental Releases from Screen Reclamation Processes Method 2, Traditional Screen Reclamation System 2

From Ink Removal Operations:
Acetone
1233 g/day to air
1270 g/day to water

From Emulsion Remover:
Sodium Hypoclorite
75 g/day to water

From Haze Remover:
Acetone:
166 g/day to air
Xylenes:
47 g/day to air
Mineral Spirits:
15.3 g/day to air
119 g/day to water
Cyclohexanone:
58.1 g/day to air
76 g/day to water

Table V-61
Summary of Estimated Daily Environmental Releases from a Hypothetical Facility Using Method 2, Traditional System 2

Substance:	To Air:	To Water:	To Landfill:
Acetone	1,399 g/day	1270[a] g/day	1270[a] g/day
Sodium Hypoclorite		75 g/day	
Mineral Spirits	15.3 g/day	119 g/day	
Xylenes	47 g/day		
Cyclohexanone	58.1 g/day	76 g/day	

[a]1270 g/day is estimated to be releases from the rags. This release from the rags will be either to landfill or to water. If the release is to water through the laundry, then the landfill column is blank. If the release is to landfill, then the landfill column will be 1270 g/day and the water column will be empty. This is true of all of the ink remover chemicals. For our purposes, the rest of the assessment assumes release to water only, since we are not assessing landfill releases.

Releases to Water from a Single Facility

Table V-62
Estimated Releases to Water from Method 2, Traditional System 2

Substance	Amount Released to Water from Facility	Waste water Treatment Removal Efficiency	Amount to Water After Waste water Treatment	Daily Stream Concentration, ug/L[a] for 1000 MLD Receiving Water
Acetone	1270 g/day	87%	165 g/day	0.2
Cyclohexanone	76 g/day	83%	12.9 g/day	1×10^{-2}
Mineral spirits	119 g/day	94%	7.14 g/day	7×10^{-3}
Sodium Hypoclorite	75 g/day	>>99%	<<1 g/day	$<<1 \times 10^{-3}$

[a]ug/L is Micrograms per liter, which is parts per billion for a substance in water. MLD is Million liters per day.

Releases to Water from Multiple Screen Printers

The concentrations listed in the chart above are relatively low. However, in the local area there may be many screen printers, all of which are connected to the same waste treatment facility. The concentration in the stream would be the combined amounts of all of the releases in the stream, which could be significant, even if the release from one screen printing facility is not.

To demonstrate the combined effects, the multiple screen printing facilities in St. Louis County, Missouri were picked as an example. The Dun and Bradstreet data shows 135 screen printing facilities in St. Louis County. We are assuming that the waste water from all of these is going to the St. Louis County Sewer Company, which releases into the Meramec River. Less than five kilometers downstream is the Kirkwood Water Department, and just about ten kilometers downstream is an intake for the St. Louis County Water company. These service an estimated 28 thousand people and one million people, respectively. The mean flow of the river is 7895 million liters per day (MLD), and is not any larger at the drinking water intakes than it is at the release point.

Table V-63
Estimated Cumulative Releases for St. Louis County, MO
Method 2, Traditional System 2

Substance	Total Amount Released to Water from All Facilities	Waste water Treatment Removal Efficiency	Amount to Water After Waste water Treatment	Average Concentration in Meramec River, ug/L (ppb)
Acetone	171 kg/day	87%	22.3 kg/day	3
Mineral Spirits	16.1 kg/day	94%	964 g/day	0.1
Cyclohexanone	10.3 kg/day	83%	1.7 kg/day	0.2
Sodium Hypochlorite	10.1 kg/day	>>99%	<< 100 g/day	<< 1 x 10^{-1}

[b] > > is very much greater than, < < is very much less than.

Releases to Air from Individual Screen Printing Facilities

Table V-64
Air Release, Concentration and Potential Dose Estimates from a Single Model Facility
Method 2, Traditional System 2

Substance	Amount of Releases per day	Highest Average Concentration 100 M away	Annual Potential Dose, mg/year[a]
Mineral Spirits	15.3 g/day	3 x 10^{-2} ug/m^3	0.2
Acetone	1399 g/day	3 ug/m^3	20
Xylenes	47 g/day	9 x 10^{-2} ug/m^3	0.7
Cyclohexanone	58.1 g/day	1 x 10^{-1} ug/m^3	0.7

[a] This estimates doses for people living 100 Meters from the hypothetical facility. The actual number of people who would fall into this range can be determined from census data, if the facility location is known. The model used to calculate concentrations is more completely explained in the Overview by Media-Air Section in Chapter III. To calculate the annual potential dose, the concentration is multiplied by the amount a person will breathe (20 m^3/day) and the number of days per year (365), and the units are converted to mg/year by dividing by 1000.

General Population Risk Conclusions and Observations

- Health risks to the general population from both air and water exposures are very low for Method 2, Traditional System 2.

Although air releases were evaluated for only a single facility, it is very unlikely that an analysis of cumulative air releases would lead to different risk conclusions. Examples of general population exposure and risk estimates are shown for Method 2, Traditional System 1 in Methods 1 and 2 and Alternative System Chi in Method 2; please reference these sections as illustrative examples. Hazard Quotient values below one indicate very low risk. Margin-of-Exposure (MOE) values above 100 for a NOAEL or above 1000 for a LOAEL indicate very low risk.

Ecological Risks From Water Releases Of Screen Reclamation Chemicals

- None of the other components of Method 2, Traditional System 2 reached an ecotoxicity concern concentration, even when considering the cumulative releases from all shops in the area.

- None of the single facility releases of Method 2, Traditional System 2 reach an ecotoxicity concern concentration.

The following table summarizes the exposure and risk estimates for cumulative releases of Traditional System 2. The analogous figures for single facilities show much lower exposure and risk levels.

Table V-65
Estimated Cumulative Releases to Water for St. Louis County, MO
Screen Reclamation Method 2, Traditional System 2

Substance	Total Amount Released to Water from All Facilities	Waste water Treatment Removal Efficiency	Amount to Water After Waste water Treatment	Daily Stream Conc. in Meramec River, ug/L (ppb)	ECO CC (ug/L)	ECO RISK INDICATOR (STREAM CONC/ ECO CC)
Acetone	171 kg/day	87%	22.3 kg/day	3	7600	$4x10^{-4}$
Mineral Spirits	16.1 kg/day	94%	964 g/day	0.1	1	0.1
Cyclohexanone	10.3 kg/day	83%	1.7 kg/day	0.2	2800	$7x10^{-5}$
Sodium Hypochlorite	10.1 kg/day	>>99%	<< 100 kg/day	$<< 1 \times 10^{-1}$	20	$<<1 \times 10^{-2}$

Performance

The performance of this system was not demonstrated at the Screen Printing Technical Foundation or at volunteer printing facilities. Since this system is commonly used in many screen printing shops, it was decided to use the limited resources available for a performance demonstration to evaluate alternatives to the traditionally used product systems.

Cost

Because the performance of this system was not determined in this project, the total cost of using this system was also not calculated.

Traditional System 3

Formulation

Ink Remover:	100% Lacquer Thinner, consisting of:
	30% Methyl ethyl ketone
	15% n-butyl acetate
	5% Methanol
	20% Naphtha light aliphatic
	20% Toluene
	10% Isobutyl isobutyrate
Emulsion Remover:	12 wt% Sodium hypochlorite/88 % water
Haze Remover:	10% Xylene
	30% Acetone
	30% Mineral spirits
	30% Cyclohexanone

Occupational Exposure

Table V-66
Occupational Exposure Estimates for Method 2, Traditional System 3

System	Inhalation (mg/day)				Dermal (mg/day)	
	I	II	III	IV	Routine	Immersion
Ink Remover						
Methyl ethyl ketone(2-butanone)	165	5.3	3	20	468	2180
Butyl acetate, normal	44	1.3	1	5.3	234	1090
Methanol	27	4.7	2	15	78	364
Naphtha, light aliphatic	98	1.6	1	6.2	312	1460
Toluene	110	2.3	1	9.2	312	1460
Isobutyl isobutyrate	7	0.4	0	1.7	156	728
Emulsion Remover (Bleach)						
Sodium hypochlorite	0	0	0	0	187	874
Water	0	0	0	0	1370	874
Haze Remover						
Xylenes (mixed isomers)	21	0.9	1	0	156	728
Acetone	64	11	5	0	468	2180
Mineral spirits- light hydrotreated	7	0.1	0	0	468	2180
Cyclohexanone	27	0.3	0	0	468	2180

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry.

Occupational Risk Conclusions and Observations

Ink Remover and Haze Remover

- Hazard quotient calculations indicate clear concerns for both toluene and methyl ethyl ketone with respect to chronic dermal and inhalation exposures to workers using these chemicals in ink removal.
- Hazard quotient calculations indicate marginal concerns for chronic inhalation exposure to workers using methanol in ink removal.
- Hazard quotient calculations indicate clear concerns for chronic dermal and inhalation exposures to workers using acetone in haze removal.

Table V-67
Occupational Risk Estimates for Method 2, Traditional System 3

Name	Hazard Quotient[b]			Margin Of Exposure[a]					
		Dermal		Inhalation		Dermal			
						Routine		Immersion	
	Inhalation	Routine	Immersion	NOAEL[c]	LOAEL[d]	NOAEL	LOAEL	NOAEL	LOAEL
Ink Remover									
Methyl ethyl ketone (2-butanone)	9.29	23	103	NA	NA	NA	NA	NA	NA
Butyl acetate normal	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methanol	1.4	2.2	10	NA	NA	NA	NA	NA	NA
Aromatic solvent naphtha	NA	NA	NA	NA	NA	NA	NA	NA	NA
Toluene	17	44	208	NA	NA	NA	NA	NA	NA
Isobutyl isobutyrate	NA	NA	NA	NA	NA	NA	NA	NA	NA
Emulsion Remover (Bleach)									
Sodium hypochlorite	NA	NA	NA	NA	NA	NA	NA	NA	NA
Water	NA	NA	NA	NA	NA	NA	NA	NA	NA
Haze Remover									
Xylenes (mixed isomers)	0.2	1.1	5.2	NA	NA	NA	NA	NA	NA
Acetone	11	66	311	NA	NA	NA	NA	NA	NA
Mineral spirits- light hydrotreated	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cyclohexanone	0.07	1.3	6.2	180	NA	NA	NA	NA	NA

[a]Margin of Exposure (MOE) values above 100 for a NOAEL and 1000 for a LOAEL indicate low risk.
[b]Hazard Quotient is the ratio of the estimated chronic dose/exposure level to the Reference Dose (RfD) or the Reference Concentration (RfC). Hazard Quotient values less than 1 imply that adverse effects are very unlikely to occur.
[c]NOAEL means No Observed Adverse Effect Level.
[d]LOAEL means Lowest Observed Adverse Effect Level.

- Hazard quotient calculations indicate marginal concerns for chronic dermal exposures to workers using cyclohexanone in haze removal.

- Margin-of-exposure calculations indicate very low concern for developmental and reproductive toxicity risks from inhalation of cyclohexanone. Reproductive and developmental toxicity risks from dermal exposures to cyclohexanone could not be quantified.

- Dermal exposures to workers using mineral spirits in haze removal can be high, although the risks from mineral spirits could not be quantified because of limitations in hazard data.

Emulsion Removers (All Systems)

- All of the systems that employ an emulsion remover (all systems except Beta) use either a strong oxidizer such as hypochlorite or periodate or a strong base such as sodium hydroxide. The haze removers in Alpha, Epsilon, Gamma, Mu, Omicron, and Theta also contain these compounds. All of these materials present a high concern for skin and eye irritation and tissue damage if workers are exposed in the absence of proper protective clothing. None of the emulsion removers present significant inhalation risks.

Environmental Releases

Table V-68
Estimated Environmental Releases in Screen Cleaning Operations
Method 2, Traditional System 3

System	Release Under Each Scenario (g/day)						
	I			II	III	IV	
	air	water	land	air	air	air	water
Ink Remover							
Methyl ethyl ketone(2-butanone)	344	0	0	11	5.7	42	363
Butyl acetate, normal	92	0	80	2.6	1.5	11	191
Methanol	57	0	0	9.8	4.1	30	37
Naphtha, light aliphatic	204	0	25	3.2	1.7	13	257
Toluene	229	0	0	4.8	2.6	19	251
Isobutyl isobutyrate	15	0	100	0.8	0.5	3.4	132
Emulsion Remover (Bleach)							
Sodium hypochlorite	0	75	0	0	0	0	0
Water	0	546	0	0	0	0	0
Haze Remover							
Xylenes (mixed isomers)	44	0	0	1.9	1.1	0	0
Acetone	133	0	0	22	11	0	0
Mineral spirits- light hydrotreated	15	119	0	0.2	0.1	0	0
Cyclohexanone	57	76	0	0.7	0.4	0	0

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry

Table V-69
Summary of Estimated Daily Environmental Releases from a Hypothetical Facility Using Method 2, Traditional System 3

Substance:	To Air:	To Water:	To Landfill:
Methyl ethyl ketone	403 g/day	363 g/day at laundry	
n-butyl Acetate	107 g/day	191 g/day at laundry[a]	80 g/day[a]
Methanol	101 g/day	37 g/day at laundry	
Naphtha, light aliphatic	222 g/day	257 g/day at laundry	25 g/day
Toluene	255 g/day	251 g/day at laundry	
Isobutyl isobutyrate	19.7 g/day	132 g/day at laundry	100 g/day
Bleach		75 g/day	
Mineral Spirits	15.3 g/day	119 g/day	
Acetone	166 g/day		
Xylenes	47 g/day		
Cyclohexanone	58.1 g/day	76 g/day	

[a]The landfill number is the amount estimated to be releases from the rags. This release from the rags will be either to landfill or to water. If the release is to water through the laundry, then the landfill column is blank. This is true of all of the ink remover chemicals. For our purposes, the rest of the assessment assumes release to water only, since we are not assessing landfill releases.

Releases to Water from a Single Facility

Table V-70
Estimated Releases to Water from Traditional Formulations from Screen Reclamation at a Single Facility
Method 2, Traditional System 3

Substance	Amount Released to Water from Facility	Waste water Treatment Removal Efficiency	Amount to Water After Waste water Treatment	Mean Daily Concentration, ug/L[a] for 1000 MLD Receiving Water
Methyl Ethyl Ketone	363 g/day at laundry	84%	58 g/day	6×10^{-2}
n-butyl acetate	191 g/day at laundry	97%	5.7 g/day	6×10^{-3}
Methanol	37 g/day at laundry	97%	1.1 g/day	1×10^{-3}
Naphtha, light aliphatic	257 g/day at laundry	94%	15 g/day	2×10^{-2}
Toluene	251 g/day at laundry	92%	20 g/day	2×10^{-2}
Isobutyl isobutyrate	132 g/day at laundry	98%	2.6 g/day	3×10^{-3}
Mineral Spirits	119 g/day	94%	7.1 g/day	7×10^{-3}
Cyclohexanone	76 g/day	83%	13 g/day	1×10^{-2}
Sodium Hypochlorite[b]	75 g/day	100 %	0	0

[a]ug/L is Micrograms per liter, which is parts per billion for a substance in water. MLD is Million liters per day.
[b]Concentrated solutions of sodium hypochlorite will kill the biota which degrade organic chemicals (the other substances listed in the table) during waste water treatment. This could cause problems at the waste water treatment plant, reducing the waste water treatment efficiency for the other compounds sent to the plant.

Releases to Water from Multiple Screen Printers

The concentrations listed in the chart above are relatively low. However, in the local area there may be many screen printers, all of which are connected to the same waste treatment facility. The concentration in the stream would be the combined amounts of all of the releases in the stream, which could be significant, even if the release from one screen printing facility is not.

To demonstrate the combined effects, the multiple screen printing facilities in St. Louis County, Missouri were picked as an example. The Dun and Bradstreet data shows 135 screen printing facilities in St. Louis County. We are assuming that the waste water from all of these is going to the St. Louis County Sewer Company, which releases into the Meramec River. Less than five kilometers downstream is the Kirkwood Water Department, and just about ten kilometers downstream is an intake for the St. Louis County Water company. These service an

estimated 28 thousand people and one million people, respectively. The mean flow of the river is 7895 million liters per day (MLD), and is not any larger at the drinking water intakes than it is at the release point.

Table V-71
Estimated Cumulative Releases for St. Louis County, MO
Method 2, Traditional System 3

Substance	Total Amount Released to Water from All Facilities	Waste water Treatment Removal Efficiency	Amount to Water After Waste water Treatment	Average Concentration in Meramec River, ug/L (ppb)
Methyl ethyl ketone	49 kg/day	84%	7.8 kg/day	1
n-butyl acetate	26 kg/day	97%	8×10^{-1} kg/day	1×10^{-1}
Methanol	5 kg/day	97%	150 g/day	2×10^{-2}
Naphtha, light aliphatic	35 kg/day	94%	2.1 kg/day	3×10^{-1}
Toluene	34 kg/day	92%	2.7 kg/day	3×10^{-1}
Isobutyl isobutyrate	18 kg/day	98%	360 g/day	4×10^{-2}
Mineral Spirits	16 kg/day	94%	960 g/day	1×10^{-1}
Cyclohexanone	10 kg/day	83%	1.7 kg/day	2×10^{-1}
Sodium Hypochlorite	10 kg/day	>> 99%	<<100 g/day	$<<1 \times 10^{-2}$

Releases to Air from Individual Screen Printing Facilities

Table V-72
Air Release, Concentration and Potential Dose Estimates from a Single Model Facility
Method 2, Traditional System 3

Substance	Amount of Releases per day	Highest Average Concentration 100 M away	Annual Potential Dose, mg/year[a]
Methyl Ethyl Ketone	403 g/day	8×10^{-1} ug/m^3	6
n-butyl acetate	107 g/day	2×10^{-1} ug/m^3	1
Methanol	101 g/day	2×10^{-1} ug/m^3	1
Naphtha, light aliphatic	222 g/day	4×10^{-1} ug/m^3	3
Toluene	255 g/day	5×10^{-1} ug/m^3	4
Isobutyl isobutyrate	19.7	4×10^{-2} ug/m^3	0.3
Mineral Spirits	15.3 g/day	3×10^{-2} ug/m^3	0.2
Acetone	166 g/day	3×10^{-1} ug/m^3	2
Xylenes	47 g/day	9×10^{-2} ug/m^3	0.7
Cyclohexanone	58.1 g/day	1×10^{-1} ug/m^3	0.7

[a]This estimates doses for people living 100 Meters from the hypothetical facility. The actual number of people who would fall into this range can be determined from census data, if the facility location is known. The model used to calculate concentrations is more completely explained in the Overview by Media-Air Section in Chapter III. To calculate the annual potential dose, the concentration is multiplied by the amount a person will breathe (20 m^3/day) and the number of days per year (365), and the units are converted to mg/year by dividing by 1000.

General Population Risk Conclusions and Observations

- Health risks to the general population from both air and water exposures are very low for Method 2, Traditional System 3.

Although air releases were evaluated for only a single facility, it is very unlikely that an analysis of cumulative air releases would lead to different risk conclusions. Examples of general population exposure and risk estimates are shown for Method 2, Traditional System 1. Hazard Quotient values below one indicate very low risk. Margin-of-Exposure (MOE) values above 100 for a NOAEL or above 1000 for a LOAEL indicate very low risk.

Table V-73
Risks from Potential Drinking Water Exposures
Screen Reclamation Method 2, Traditional System 3

Substance	Daily Stream Concentration in Meramec River, ug/L (ppb)	Daily dose from Drinking Water (mg/kg)	RfD (mg/kg)	Hazard Quotient (dose/RfD)
Methyl ethyl ketone	1	$3x10^{-5}$	0.6	$5x10^{-5}$
n-butyl acetate	1×10^{-1}	$3x10^{-6}$	not available	
Methanol	2×10^{-2}	$6x10^{-7}$	0.5	$1x10^{-6}$
Naphtha, light aliphatic	3×10^{-1}	$9x10^{-6}$	not available	
Toluene	3×10^{-1}	$9x10^{-6}$	0.2	$4x10^{-5}$
Isobutyl isobutyrate	4×10^{-2}	$1x10^{-6}$	not available	
Mineral Spirits	1×10^{-1}	$3x10^{-6}$	not available	
Cyclohexanone	2×10^{-1}	$6x10^{-6}$	5	$1x10^{-6}$
Sodium Hypochlorite	$<<1 \times 10^{-2}$	$<<3x10^{-7}$	not available	

Table V-74
Risk Estimates from Ambient Air Releases from a Single Model Facility
Screen Reclamation Method 2, Traditional System 3

Substance	Highest Avg Concentration 100 M away	Daily Potential Dose, (mg/kg)	RfD/RfC (mg/kg, mg/m3)	Hazard Quotient(Dose or Conc/RfD or RfC)
Methyl Ethyl Ketone	8×10^{-1} ug/m^3	2×10^{-4}	1 mg/m^3	8×10^{-4}
n-butyl acetate	2×10^{-1} ug/m^3	4×10^{-5}	not available	
Methanol	2×10^{-1} ug/m^3	4×10^{-5}	0.5 mg/kg	8×10^{-5}
Naphtha, light aliphatic	4×10^{-1} ug/m^3	1×10^{-4}	not available	
Toluene	5×10^{-1} ug/m^3	2×10^{-4}	0.4 mg/m^3	1×10^{-3}
Isobutyl isobutyrate	4×10^{-2} ug/m^3	1×10^{-5}	not available	
Mineral Spirits	3×10^{-2} ug/m^3	8×10^{-6}	not available	
Acetone	3×10^{-1} ug/m^3	8×10^{-5}	0.1 mg/kg	8×10^{-4}
Xylenes	9×10^{-2} ug/m^3	3×10^{-5}	2 mg/kg	1×10^{-5}
Cyclohexanone	1×10^{-1} ug/m^3	3×10^{-5}	5 mg/kg	6×10^{-6}

Ecological Risks From Water Releases Of Screen Reclamation Chemicals

- None of the other components of Method 2, Traditional System 3 reached an ecotoxicity concern concentration, even when considering the cumulative releases from all shops in the area.

- None of the single facility releases of Method 2, Traditional System 3 reach an ecotoxicity concern concentration.

The following table summarizes the exposure and risk estimates for cumulative releases of Traditional System 3. The analogous figures for single facilities show much lower exposure and risk levels.

Table V-75
Estimated Cumulative Releases for St. Louis County, MO
Screen Reclamation Method 2, Traditional System 3

Substance	Total Amount Released to Water from All Facilities	Waste water Treatment Removal Efficiency	Amount to Water After Waste water Treatment	Daily Stream Conc. in Meramec River, ug/L (ppb)	ECO CC (ug/L)	ECO RISK INDICATOR (STREAM CONC/ ECO CC)
Methyl ethyl ketone	49 kg/day	84%	7.8 kg/day	1	4500	$2x10^{-4}$
n-butyl acetate	26 kg/day	97%	8×10^{-1} kg/day	1×10^{-1}	140	$7x10^{-4}$
Methanol	5 kg/day	97%	150 g/day	2×10^{-2}	9000	$2x10^{-6}$
Naphtha light aliphatic	35 kg/day	94%	2.1 kg/day	3×10^{-1}	5	0.06
Toluene	34 kg/day	92%	2.7 kg/day	3×10^{-1}	110	$3x10^{-3}$
Isobutyl isobutyrate	18 kg/day	98%	360 g/day	4×10^{-2}	80	$5x10^{-4}$
Mineral Spirits	16 kg/day	94%	960 g/day	1×10^{-1}	1	0.1
Cyclohexanone	10 kg/day	83%	1.7 kg/day	2×10^{-1}	2800	$7x10^{-5}$
Sodium Hypochlorite	10 kg/day	>> 99%	<<100 g/day	$<<1 \times 10^{-2}$	<20	~0.05

Performance

General Summary of Traditional System 3 Performance

The performance of Traditional System 3 was demonstrated at SPTF. This product system consisted of an ink remover (lacquer thinner), an emulsion remover (sodium hypochlorite or bleach), and a haze remover. The ink remover and the haze remover were selected based on general chemical formulations that were identified by manufacturers as the most common types of products currently used in the screen printing industry. SPTF did not use the haze remover suggested by the manufacturers due to concerns about the volatility and hazards of the product; instead a commonly used, commercially available haze remover containing potassium hydroxide and tetrahydrofurfuryl alcohol was used. Unlike the alternative systems, Traditional Product System 3 was only tested at SPTF; no demonstrations were conducted at volunteer printing facilities. Traditional System 3 was tested following the same procedure as was used for alternative system testing at SPTF (see Appendix F for details of the testing methodology and test parameters).

Overall, SPTF described the ink remover (lacquer thinner) as very difficult to work with, and incompatible with water-based ink systems. Using bleach as an emulsion remover was also inefficient: it required a lot of time and effort to remove the stencil. The haze remover worked very well on the screens with solvent-based ink and UV ink, but it was not tested on the screen with water-based ink.

Traditional System 3 Profile

The products in Traditional System 3 were used to reclaim screens as follows:

- Ink Removal Card up the excess ink from the screen with cardboard or plastic squeegees. Spray the screen surface with the ink remover and wipe up the dissolved ink and solvent with an absorbent rag or cloth. Repeat spraying on the product and wiping off the ink until the ink is removed and little comes off on the cloth.

- Emulsion Removal Place the screen in the washout sink and spray both sides of the stencil area so that the product evenly covers the stencil. Use a soft brush to loosen the stencil. Scrub with the brush until the stencil is broken up in all areas. Apply more product if necessary. Wash away the stencil with a hard spray of water, preferably with a pressure washer.

- Haze Removal Mix the haze remover paste thoroughly. Brush the product on the stained areas on both sides of the wet mesh. Let stand for a maximum of 8 minutes. Rinse off the residue with a gentle water spray, followed by a high pressure water spray to remove the stain.

Traditional System 3 Performance by SPTF

Traditional System 3 was tested by SPTF on three screens (one with a solvent-based ink, one with a UV-curable ink, and one with a water-based ink). The performance of the products varied greatly with the different ink types.

On the screen with the solvent-based ink, the lacquer thinner removed the ink, but left a gray haze over the screen. The technician noted that the lacquer thinner was very difficult to use: it required a lot of wiping effort and ten rags were used to remove the ink. The stencil was affected during ink removal, either from the lacquer thinner itself or from the excessive wiping that was required to remove the ink. The emulsion remover was also very difficult to use. Three applications of the bleach were required, along with vigorous scrubbing for over 10 minutes to remove the stencil. When the stencil finally did dissolve and the screen was pressure washed, ink residue and stain remained in the image areas. The haze remover easily removed all of the ink residue and the ink stain. The screen was then left in the laboratory testing area overnight. The next day, the technician noticed that the screen had ripped sometime after the test was complete.

The performance of the traditional system was similar on the screen with UV ink. The lacquer thinner left a gray haze on the screen and the stencil started to deteriorate during the ink removal step. The UV ink screen did not require quite as much scrubbing effort as the solvent-based ink screen, and seven rags were used. The bleach performance was the same as with the solvent-based ink screen: the stencil dissolved very slowly, and an excessive amount of scrubbing, effort, and rinsing were needed to remove the stencil. After the rinse, ink residue remained in the image areas. As with the solvent-based ink screen, the haze remover easily removed the ink residue and no latent image was visible.

On the screen with the water-based ink, the lacquer thinner proved to be completely incompatible. All of the ink on the screen solidified when the lacquer thinner was applied. At

that point, the test had to be aborted and the emulsion remover and haze remover were not applied.

Traditional System 3 Performance Table

The following table highlights the observed performance of Traditional Product System 3 during the product tests performed at SPTF.

Cost

Although the performance of this system was demonstrated at SPTF, the total cost of this system was not calculated. It was determined that a cost analysis with a sodium periodate-based emulsion remover would be more representative of the products that are currently being used at screen printers. Subsequently, the traditional system cost baseline was based on Traditional System 4, not System 3.

Table V-76
Performance Summary For Traditional Product System 3

	System Component	Performance					Demonstration Conditions			
		Avg Drying Time Before Using Product	Average Quantity Applied	Average Cleaning Time	Average Effort Required	Overall System Performance	Ink type	Emulsion type	Mesh type; Thread count	Average Screen Size
Laboratory Testing at SPTF										
Solvent-based Ink	*Ink Remover*	15 mins	3.5 oz.	8.7 mins	High	Removed ink with a lot of scrubbing. Gray haze remained on entire screen.	Solvent-based	Dual-cure direct	Polyester; 245 threads/inch	360 in^2
	Emulsion Remover	24 hours	3.0 oz.	22.5 mins	High	Stencil dissolved slowly with vigorous scrubbing. Heavy ink residue and stain remained in image areas.				
	Haze Remover[a]	0 mins	1.5 oz.	11.0 mins	Low	Removed all residue and stain.				
UV-curable Ink	*Ink Remover*	15 mins	2.5 oz.	7.4 mins	Moderate	Removed ink with moderate scrubbing. A gray haze remained on the screen.	UV-cured	Dual-cure direct	Polyester; 390 threads/inch	360 in^2
	Emulsion Remover	24 hours	3.0 oz.	17.7 mins	High	Stencil dissolved slowly with vigorous scrubbing and excessive rinsing. Ink residue and stain remained in image areas.				
	Haze Remover[a]	0 mins	1.0 oz.	12.0 mins	Low	Removed all residue and stain.				
Water-based Ink	*Ink Remover*	15 mins	not recorded	not recorded	not recorded	The ink solidified across the entire screen when the ink remover was applied. Testing was stopped at this point.	Water-based	Dual-cure direct	Polyester; 245 threads/inch	360 in^2
	Emulsion Remover	not used	not used	not used	not used	Test aborted after ink remover failure.				
	Haze Remover	not used	not used	not used	not used	Test aborted after ink remover failure.				

[a] A haze remover other than the formulation specified by the manufacturer and evaluated in the risk assessment for this system was used during the performance demonstration. See General Summary of Traditional System 3 Performance for details.

Traditional System 4

Formulation

Ink Remover:	100% Lacquer Thinner, consisting of:
	30% Methyl ethyl ketone
	15% n-butyl acetate
	5% Methanol
	20% Naphtha light alipahtic
	20% Toluene
	10% Isobutyl isobutyrate
Emulsion Remover:	1% Sodium periodate/ 99% water
Haze Remover:	10% Xylene
	30% Acetone
	30% Mineral spirits
	30% Cyclohexanone

Occupational Exposure

Table V-77
Occupational Exposure Estimates for Method 2, Traditional System 4

System	Inhalation (mg/day)				Dermal (mg/day)	
	I	II	III	IV	Routine	Immersion
Ink Remover						
Methyl ethyl ketone(2-butanone)	165	5.3	3	20	468	2180
Butyl acetate normal	44	1.3	1	5.3	234	1090
Methanol	27	4.7	2	15	78	364
Naphtha, light aliphatic	98	1.6	1	6.2	312	1460
Toluene	110	2.3	1	9.2	312	1460
Isobutyl isobutyrate	7	0.4	0	1.7	156	728
Emulsion Remover (Zeta diluted 1:4)						
Sodium periodate	0	0	0	0	16	73
Water	0	0	0	0	1540	7210
Haze Remover						
Xylenes (mixed isomers)	21	0.9	1	0	156	728
Acetone	64	11	5	0	468	2180
Mineral spirits- light hydrotreated	7	0.1	0	0	468	2180
Cyclohexanone	27	0.3	0	0	468	2180

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry.

Occupational Risk Conclusions and Observations

Ink Remover and Haze Remover

- Hazard quotient calculations indicate clear concerns for both toluene and methyl ethyl ketone with respect to chronic dermal and inhalation exposures to workers using these chemicals in ink removal.
- Hazard quotient calculations indicate marginal concerns for chronic inhalation exposure to workers using methanol in ink removal.
- Hazard quotient calculations indicate clear concerns for chronic dermal and inhalation exposures to workers using acetone in haze removal.
- Hazard quotient calculations indicate marginal concerns for chronic dermal exposures to workers using cyclohexanone in haze removal.

Table V-78
Occupational Risk Estimates for Method 2, Traditional System 4

Name	Hazard Quotient[b]			Margin Of Exposure[a]					
		Dermal		Inhalation		Dermal			
						Routine		Immersion	
	Inhalation	Routine	Immersion	NOAEL[c]	LOAEL[d]	NOAEL	LOAEL	NOAEL	LOAEL
Ink Remover									
Methyl ethyl ketone (2-butanone)	9.3	22	103	NA	NA	NA	NA	NA	NA
Butyl acetate normal	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methanol	1.4	2.2	10	NA	NA	NA	NA	NA	NA
Aromatic solvent naphtha	NA	NA	NA	NA	NA	NA	NA	NA	NA
Toluene	17	44	208	NA	NA	NA	NA	NA	NA
Isobutyl isobutyrate	NA	NA	NA	NA	NA	NA	NA	NA	NA
Emulsion Remover (Zeta diluted 1:4)									
Sodium periodate	NA	NA	NA	NA	NA	NA	NA	NA	NA
Water	NA	NA	NA	NA	NA	NA	NA	NA	NA
Haze Remover									
Xylenes (mixed isomers)	0.2	1.1	5.2	NA	NA	NA	NA	NA	NA
Acetone	11	66	310	NA	NA	NA	NA	NA	NA
Mineral spirits- light hydrotreated	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cyclohexanone	0.07	1.3	6.2	180	NA	NA	NA	NA	NA

[a]Margin of Exposure (MOE) values above 100 for a NOAEL and 1000 for a LOAEL indicate low risk.
[b]Hazard Quotient is the ratio of the estimated chronic dose/exposure level to the Reference Dose (RfD) or the Reference Concentration (RfC). Hazard Quotient values less than 1 imply that adverse effects are very unlikely to occur.
[c]NOAEL means No Observed Adverse Effect Level.
[d]LOAEL means Lowest Observed Adverse Effect Level.

- Margin-of-exposure calculations indicate very low concern for developmental and reproductive toxicity risks from inhalation of cyclohexanone. Reproductive and developmental toxicity risks from dermal exposures to cyclohexanone could not be quantified.

- Dermal exposures to workers using mineral spirits in haze removal can be high, although the risks from mineral spirits could not be quantified because of limitations in hazard data.

Emulsion Removers (All Systems)

- All of the systems that employ an emulsion remover use either a strong oxidizer such as hypochlorite or periodate or a strong base such as sodium hydroxide. The haze removers in Alpha, Epsilon, Gamma, Mu, Omicron, and Theta also contain these compounds. All of these materials present a high concern for skin and eye irritation and tissue damage if workers are exposed in the absence of proper protective clothing. None of the emulsion removers present significant inhalation risks.

Environmental Releases

Table V-79
Estimated Environmental Releases in Screen Cleaning Operations
Method 2, Traditional System 4

System	Release Under Each Scenario (g/day)						
	I			II	III	IV	
	air	water	land	air	air	air	water
Ink Remover							
Methyl ethyl ketone(2-butanone)	344	0	0	11	5.7	42	363
Butyl acetate, normal	92	0	80	2.6	1.5	11	191
Methanol	57	0	0	9.8	4.1	30	37
Naphtha, light aliphatic	204	0	25	3.2	1.7	13	257
Toluene	229	0	0	4.8	2.6	19	251
Isobutyl isobutyrate	15	0	100	0.8	0.5	3.4	132
Emulsion Remover (Zeta diluted 1:4)							
Sodium periodate	0	6	0	0	0	0	0
Water	0	615	0	0	0	0	0
Haze Remover							
Xylenes (mixed isomers)	44	0	0	1.9	1.1	0	0
Acetone	133	0	0	22	11	0	0
Mineral spirits- light hydrotreated	15	119	0	0.2	0.1	0	0
Cyclohexanone	57	76	0	0.7	0.4	0	0

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry.

Table V-80
Summary of Estimated Daily Environmental Releases from a Hypothetical Facility Using Method 2, Traditional System 4

Substance:	To Air:	To Water:	To Landfill:
Methyl ethyl ketone	403 g/day	363 g/day at laundry	
n-butyl Acetate	107 g/day	191 g/day at laundry[a]	80 g/day[a]
Methanol	101 g/day	37 g/day at laundry	
Naphtha, light aliphatic	222 g/day	257 g/day at laundry	25 g/day
Toluene	255 g/day	251 g/day at laundry	
Isobutyl isobutyrate	19.7 g/day	132 g/day at laundry	100 g/day
Sodium periodate		6 g/day	
Mineral Spirits	15.3	119 g/day	
Acetone	166 g/day		
Xylenes	47 g/day		
Cyclohexanone	58.1 g/day	76 g/day	

[a]191 g/day is estimated to be releases from the rags if the rags are laundered. This release from the rags will be either to landfill or to water. If the release is to water through the laundry, then the landfill column is blank. If the release is to landfill, then the landfill column will be 80 g/day and the water column will be blank. This is true for all of the ink remover chemicals. For our purposes, the rest of the assessment assumes release to water only, since we are not assessing landfill releases.

Releases to Water from a Single Facility

Table V-81
Estimated Releases to Water from Traditional Formulations from Screen Reclamation at a Single Facility
Method 2, Traditional System 4

Substance	Amount Released to Water from Facility	Waste water Treatment Removal Efficiency	Amount to Water After Waste water Treatment	Daily Stream Concentration, ug/L[a] for 1000 MLD Receiving Water
Methyl Ethyl Ketone	363 g/day at laundry	84%	58 g/day	6×10^{-2}
n-butyl acetate	191 g/day at laundry	97%	5.7 g/day	6×10^{-3}
Methanol	37 g/day at laundry	97%	1.1 g/day	1×10^{-3}
Naphtha, light aliphatic	257 g/day at laundry	94%	15.4 g/day	2×10^{-2}
Toluene	251 g/day at laundry	92%	20 g/day	2×10^{-2}
Isobutyl isobutyrate	132 g/day at laundry	98%	2.6 g/day	3×10^{-3}
Mineral Spirits	119 g/day	94%	7.1 g/day	7×10^{-3}
Cyclohexanone	76 g/day	83%	13 g/day	1×10^{-2}
Sodium periodate	6 g/day	100 %	0	0

[a]ug/L is Micrograms per liter, which is parts per billion for a substance in water. MLD is Million liters per day.

Releases to Water from Multiple Screen Printers

The concentrations listed in the chart above are relatively low. However, in the local area there may be many screen printers, all of which are connected to the same waste treatment facility. The concentration in the stream would be the combined amounts of all of the releases in the stream, which could be significant, even if the release from one screen printing facility is not.

To demonstrate the combined effects, the multiple screen printing facilities in St. Louis County, Missouri were picked as an example. The Dun and Bradstreet data shows 135 screen printing facilities in St. Louis County. We are assuming that the waste water from all of these is going to the St. Louis County Sewer Company, which releases into the Meramec River. Less than five kilometers downstream is the Kirkwood Water Department, and just about ten kilometers downstream is an intake for the St. Louis County Water company. These service an estimated 28 thousand people and one million people, respectively. The mean flow of the river is 7895 million liters per day (MLD), and is not any larger at the drinking water intakes than it is at the release point.

Table V-82
Estimated Cumulative Releases for St. Louis County, MO
Method 2, Traditional System 4

Substance	Total Amount Released to Water from All Facilities	Waste water Treatment Removal Efficiency	Amount to Water After Waste water Treatment	Average Concentration in Meramec River, ug/L (ppb)
Methyl ethyl ketone	49 kg/day	84%	7.8 kg/day	1
n-butyl acetate	26 kg/day	97%	0.8 kg/day	1×10^{-1}
Methanol	5 kg/day	97%	150 g/day	2×10^{-2}
Naphtha, light aliphatic	35 kg/day	94%	2.1 kg/day	3×10^{-1}
Toluene	34 kg/day	92%	2.7 kg/day	3×10^{-1}
Isobutyl isobutyrate	18 kg/day	98%	360 g/day	4×10^{-2}
Mineral Spirits	16 kg/day	94%	960 g/day	1×10^{-1}
Cyclohexanone	10 kg/day	83%	1.7 kg/day	2×10^{-1}
Sodium Periodate	810 g/day	>> 99%	<< 8.1 g/day	$<<1 \times 10^{-3}$

Releases to Air from Individual Screen Printing Facilities

Table V-83
Air Release, Concentration and Potential Dose Estimates from a Single Model Facility
Method 2, Traditional System 4

Substance	Amount of Releases per day	Highest Average Concentration 100 M away	Annual Potential Dose, mg/year[a]
Methyl Ethyl Ketone	403 g/day	8×10^{-1} ug/m^3	6
n-butyl acetate	107 g/day	2×10^{-1} ug/m^3	1
Methanol	101 g/day	2×10^{-1} ug/m^3	1
Naphtha, light aliphatic	222 g/day	4×10^{-1} ug/m^3	3
Toluene	255 g/day	5×10^{-1} ug/m^3	4
Isobutyl isobutyrate	19.7	4×10^{-2} ug/m^3	3×10^{-1}
Mineral Spirits	15.3 g/day	3×10^{-2} ug/m^3	2×10^{-1}
Acetone	166 g/day	3×10^{-1} ug/m^3	2
Xylene	47 g/day	9×10^{-2} ug/m^3	7×10^{-1}
Cyclohexanone	58.1 g/day	1×10^{-1} ug/m^3	7×10^{-1}

[a]This estimates doses for people living 100 Meters from the hypothetical facility. The actual number of people who would fall into this range can be determined from census data, if the facility location is known. The model used to calculate concentrations is more completely explained in the Overview by Media-Air Section in Chapter III. To calculate the annual potential dose, the concentration is multiplied by the amount a person will breathe (20 m^3/day) and the number of days per year (365), and the units are converted to mg/year by dividing by 1000.

General Population Risk Conclusions and Observations

- Health risks to the general population from both air and water exposures are very low for Method 2, Traditional System 4.

Although air releases were evaluated for only a single facility, it is very unlikely that an analysis of cumulative air releases would lead to different risk conclusions. Examples of general population exposure and risk estimates are shown for Method 2, Traditional System 1 in Methods 1 and 2 and Alternative System Chi in Method 2; please reference these sections as illustrative examples. Hazard Quotient values below one indicate very low risk. Margin-of-Exposure (MOE) values above 100 for a NOAEL or above 1000 for a LOAEL indicate very low risk.

Ecological Risks From Water Releases Of Screen Reclamation Chemicals

- None of the other components of Method 2, Traditional System 4 reached an ecotoxicity concern concentration, even when considering the cumulative releases from all shops in the area.

- None of the single facility releases of Method 2, Traditional System 4 reach an ecotoxicity concern concentration.

The following table summarizes the exposure and risk estimates for cumulative releases of Traditional System 4. The analogous figures for single facilities show much lower exposure and risk levels.

Table V-84
Estimated Cumulative Releases for St. Louis County, MO
Screen Reclamation Method 2, Traditional System 4

Substance	Total Amount Released to Water from All Facilities	Waste Water Treatment Removal Efficiency	Amount to Water After Waste water Treatment	Daily Stream Conc. in Meramec River, ug/L (ppb)	ECO CC (ug/L)	Eco Risk Indicator (Stream Conc/ ECO CC)
Methyl ethyl ketone	49 kg/day	84%	7.8 kg/day	1	4500	$2x10^{-4}$
n-butyl acetate	26 kg/day	97%	0.8 kg/day	1×10^{-1}	140	$7x10^{-4}$
Methanol	5 kg/day	97%	150 g/day	2×10^{-2}	9000	$2x10^{-6}$
Naphtha, light aliphatic	35 kg/day	94%	2.1 kg/day	3×10^{-1}	5	0.06
Toluene	34 kg/day	92%	2.7 kg/day	3×10^{-1}	110	$3x10^{-3}$
Isobutyl isobutyrate	18 kg/day	98%	360 g/day	4×10^{-2}	80	$5x10^{-4}$
Mineral Spirits	16 kg/day	94%	960 g/day	1×10^{-1}	1	0.1
Cyclohexanone	10 kg/day	83%	1.7 kg/day	2×10^{-1}	2800	$7x10^{-5}$
Sodium Periodate	810 g/day	>> 99%	<< 8.1 g/day	$<<1 \times 10^{-3}$	<10	$\sim 10^{-4}$

Performance

The performance of this system was not demonstrated at the Screen Printing Technical Foundation or at volunteer printing facilities. Since this system is commonly used in many screen printing shops, it was decided to use the limited resources available for a performance demonstration to evaluate alternatives to the traditionally used product systems.

Cost

Table V-85
Baseline (Traditional System 4)

Cost Element Description		Traditional System 4
Facility Characteristics		
Average screen size (in^2)		2,127
Average # screens/day		6
Cost Elements per Screen		
Labor	Time spent applying, scrubbing, and removing reclamation products (min) Cost ($)	24.4 5.33
Materials and Equipment	# of rags used Cost ($)	3 0.45
Reclamation Product Use	Ink Remover Average Volume (oz.) Cost ($)	 8.0 0.22
	Emulsion Remover Average Volume (oz.) Cost ($)	 3.5 0.13
	Haze Remover Average Volume (oz.) Cost ($)	 3.0 0.12
Hazardous Waste Disposal	Amount (g) Cost ($)	34 0.02
Totals		
Total Cost ($/screen)		6.27
Total Cost ($/year)		9,399

Note: For additional information regarding product performance see performance demonstration summaries.

Product System Alpha

Formulation

Ink Remover:	Aromatic solvent naphtha
	Propylene glycol series ethers
Emulsion Remover:	Sodium periodate/water
Haze Remover:	Alkali/Caustic
	Tetrahydrofurfuryl alcohol
	Water

Occupational Exposure

Table V-86
Occupational Exposure Estimates for Method 2, Alternative System Alpha

System	Inhalation (mg/day)				Dermal (mg/day)	
	I	II	III	IV	Routine	Immersion
Ink Remover						
Aromatic solvent naphtha	13	0.1	0	0.2	1250	5820
Propylene glycol series ethers	56	0.6	0	2.6	312	1460
Emulsion Remover (diluted to 0.8%)						
Sodium periodate	0	0	0	0	12	58
Water	0	0	0	0	1550	7220
Haze Remover						
Alkali/Caustic	0	0	0	0	390	1820
Tetrahydrofurfuryl alcohol	1	0.1	0	0	234	1090
Water	0	0	0	0	936	4370

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry.

Table V-87
Occupational Risk Estimates for Alternative System Alpha

Name	Hazard Quotient[b]			Margin Of Exposure[a]					
		Dermal		Inhalation		Dermal			
						Routine		Immersion	
	Inhalation	Routine	Immersion	NOAEL[c]	LOAEL[d]	NOAEL	LOAEL	NOAEL	LOAEL
Ink Remover									
Aromatic solvent naphtha	NA	NA	NA	NA	NA	NA	NA	NA	NA
Propylene glycol series ethers	1.4	7.4	34		230	NA	NA	NA	NA
Emulsion Remover (diluted to 0.8%)									
Sodium periodate	NA	NA	NA	NA	NA	NA	NA	NA	NA
Water	NA	NA	NA	NA	NA	NA	NA	NA	NA
Haze Remover									
Alkali/Caustic	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tetrahydrofurfuryl alcohol	NA	NA	NA	NA	NA	NA	NA	NA	NA
water	NA	NA	NA	NA	NA	NA	NA	NA	NA

[a]Margin of Exposure (MOE) values above 100 for a NOAEL and 1000 for a LOAEL indicate low risk.
[b]Hazard Quotient is the ratio of the estimated chronic dose/exposure level to the Reference Dose (RfD) or the Reference Concentration (RfC). Hazard Quotient values less than 1 imply that adverse effects are very unlikely to occur.
[c]NOAEL means No Observed Adverse Effect Level.
[d]LOAEL means Lowest Observed Adverse Effect Level.

Occupational Risk Conclusions and Observations

Ink Remover and Haze Remover

- Hazard quotient calculations indicate marginal concerns for chronic inhalation exposure to workers using propylene glycol series ethers in ink removal. Possible concerns also exist for chronic dermal exposure to propylene glycol series ethers based on the calculated hazard quotients, which assume 100% dermal absorption. If the actual dermal absorption rate of propylene glycol series ethers is significantly lower, this concern would be significantly reduced or eliminated.

- Inhalation exposures to propylene glycol series ethers also present possible concerns for developmental toxicity risks, based on margin-of-exposure calculations.

- Dermal exposures to other chemicals used in ink removal or haze removal can be high, although the risks could not be quantified because of limitations in hazard data.

Emulsion Removers (All Systems)

- All of the systems that employ an emulsion remover use either a strong oxidizer such as hypochlorite or periodate or a strong base such as sodium hydroxide. The haze removers in Alpha, Epsilon, Gamma, Mu, Omicron, and Theta also contain these compounds. All of these materials present a high concern for skin and eye irritation and tissue damage if workers are exposed in the absence of proper protective clothing. None of the emulsion removers present significant inhalation risks.

Environmental Releases

Table V-88
Estimated Environmental Releases in Screen Cleaning Operations
Method 2, Alternative System Alpha

System	Release Under Each Scenario (g/day)						
	I			II	III	IV	
	air	water	land	air	air	air	water
Ink Remover							
Aromatic solvent naphtha	27	0	473	0.1	0.1	0.5	1080
Propylene glycol series ethers	117	0	8	1.3	0.7	5.4	265
Emulsion Remover (diluted to 0.8%)							
Sodium periodate	0	5	0	0	0	0	0
Water	0	616	0	0	0	0	0
Alpha - Haze Remover							
Alkali/Caustic	0	133	0	0	0	0	0
Tetrahydrofurfuryl alcohol	1.5	78	0	0.1	0.1	0	0
Water	0	319	0	0	0	0	0

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry.

Table V-89
Summary of Estimated Daily Environmental Releases from a Hypothetical Facility
Using Screen Reclamation Method 2, Alternative System Alpha

Substance:	To Air:	To Water:	To Landfill:
Aromatic solvent naphtha	27.7 g/day	1080 g/day at laundry	473 g/day
Propylene glycol series ethers	124 g/day	265 g/day at laundry	8 g/day
Sodium periodate		5 g/day	
Alkali/caustic		133 g/day	
Tetrahydrofurfuryl alcohol	1.7 g/day	78 g/day	

Releases to Water from a Single Facility

Table V-90
Estimated Releases to Water from Traditional Formulations from Screen Reclamation at a Single Facility Using Screen Reclamation Method 2, Alternative System Alpha

Substance	Amount Released to Water from Facility	Waste water Treatment Removal Efficiency	Amount to Water After Waste water Treatment	Daily Stream Concentration, ug/L[a] for 1000 MLD Receiving Water
Aromatic solvent naphtha	1080 g/day at laundry	92-96 %	43 g/day	4×10^{-2}
Propylene glycol series ethers	265 g/day at laundry	83-84 %	45.1 g/day	5×10^{-2}
Sodium periodate	5 g/day	100 %	0	
Alkali/caustic	133 g/day	100 %	0	
Tetrahydrofurfuryl alcohol	78 g/day	97 %	2.3 g/day	2×10^{-3}

[a]ug/L is Micrograms per liter, which is parts per billion for a substance in water. MLD is Million liters per day.

Releases to Air from Individual Screen Printing Facilities

Table V-91
Air Release, Concentration and Potential Dose Estimates from a Single Model Facility Using Screen Reclamation Method 2, Alternative System Alpha

Substance	Amount of Releases per day	Highest Average Concentration 100 M away	Annual Potential Dose, mg/year[a]
Aromatic solvent naphtha	27.7 g/day	5.6×10^{-2} ug/m^3	4×10^{-1}
Propylene glycol series ethers	124 g/day	2.5×10^{-1} ug/m^3	2
Tetrahydrofurfuryl alcohol	1.7 g/day	3×10^{-3} ug/m^3	2×10^{-2}

[a]This estimates doses for people living 100 Meters from the hypothetical facility. The actual number of people who would fall into this range can be determined from census data, if the facility location is known. The model used to calculate concentrations is more completely explained in the Overview by Media-Air Section in Chapter III. To calculate the annual potential dose, the concentration is multiplied by the amount a person will breathe (20 m^3/day) and the number of days per year (365), and the units are converted to mg/year by dividing by 1000.

General Population Risk Conclusions and Observations

- Health risks to the general population from both air and water exposures are very low for Method 2, Alternative System Alpha.

Although air releases were evaluated for only a single facility, it is very unlikely that an analysis of cumulative air releases would lead to different risk conclusions. Examples of general population exposure and risk estimates are shown for Method 2, Traditional System 1 in Methods 1 and 2 and Alternative System Chi in Method 2; please reference these sections as illustrative examples. Hazard Quotient values below one indicate very low risk. Margin-of-Exposure (MOE) values above 100 for a NOAEL or above 1000 for a LOAEL indicate very low risk.

Ecological Risks From Water Releases Of Screen Reclamation Chemicals

- None of the single facility releases of Method 2, Alternative System Alpha reach an ecotoxicity concern concentration.

Performance

General Summary of Alternative System Alpha Performance, and Related Variables

This product system consisted of an ink remover, emulsion remover, and a haze remover. The products were demonstrated at Facilities 8, 13, and 14. Facility 8 prints labels, nameplates, and graphic overlays. They reclaimed 48 screens over 4 weeks of demonstrations using solvent-based inks. Facility 13 prints store displays, decals, and outdoor signs, and they reclaimed 13 screens using UV-cured and solvent-based inks during the 2 weeks they participated in the demonstrations. Facility 14 prints metal nameplates, vinyl pressure sensitive decals, and signs. They used solvent-based inks during the three weeks they used Alternative System Alpha and they reclaimed 36 screens.

Facility 8 reported that the ink remover worked well most of the time, but results were inconsistent and some extra scrubbing was required to achieve the desired results. Performance was improved if the ink remover was sprayed on both the scrubbing rag and the screen. The ink remover did not seem to work at all with epoxy inks. Facility 13 also reported that the ink remover required more time and scrubbing than their usual product. Facility 14 reported that the ink remover worked as well as their usual product. One screen reclamation employee at this facility reported that the ink remover worked particularly well with their vinyl inks.

At Facility 8, the emulsion remover worked satisfactorily only if the screen was rinsed with hot water before applying the product. Facility 13 reported that the emulsion remover did not work as efficiently as their usual product, taking more time to dissolve the stencil and more scrubbing, even at full strength. Facility 14 reported that the emulsion remover worked as well as their usual product and required less effort than the regular product with the same positive results. The only negative feature mentioned by Facility 14 was that the emulsion remover left a slight green tint on the screen, but this tint was removed by the alternative haze remover.

The haze remover performance varied between the three facilities. At Facility 8, the haze remover removed the ink stain on most of the screens, however, it did not sufficiently remove haze from about 20% of the screens. These screens had to be cleaned again with their standard

product. Facility 13 thought that the haze remover did not work at all, and required extra scrubbing and follow up use with their regular product. Facility 14 initially reported that the haze remover performance was average, but another reclaimer said that it did not work as well as their usual product.

Alternative System Alpha Profile

The manufacturer recommends applying Product System Alpha as follows:

- Ink Remover. Card up as much ink as possible with plastic squeegees or cardboard. Spray the screen surface with the ink remover and wipe up the dissolved ink and solvent with an absorbent rag or cloth. Repeat spraying on the ink remover and wiping it off until the ink is removed, and little comes off on the cloth.

- Emulsion Remover. Dilute the emulsion remover as instructed on the label and pour it into a spray bottle. Place the screen in a washout sink and spray both sides of the stencil so that the product evenly covers the stencil. Using a soft brush, scrub the stencil until it is broken up in all areas. Apply more emulsion remover if necessary. Wash away the stencil with a pressure washer (a 1000 psi pressure washer was used at SPTF).

- Haze Remover. Thoroughly mix the haze remover paste. Wet the screen before applying the haze remover. Scoop out the paste from the container and apply the it to a brush. Brush the haze remover into the stained areas on both sides mesh. Allow the haze remover to stand for a maximum of 8 minutes. Rinse the screen with a gentle water spray, followed by a high pressure wash.

Alternative System Performance at SPTF

Alternative System Alpha was tested at SPTF on two screens (one with a solvent-based ink, and one with a UV-curable ink). This product system is not recommended for use with water-based inks. On the screen with the solvent-based ink, the ink dissolved well with moderate scrubbing. On the screen with the UV ink, the ink dissolved more easily and minimal scrubbing was needed. Four wipes were used to clean each screen.

On both screens, the emulsion remover dissolved the stencil with moderate scrubbing effort, leaving no emulsion stain. There was a moderate ink stain remaining on the solvent-based ink screen after emulsion removal, but the application of the haze remover removed the stain completely. On the screen with UV ink, a light stain remained after emulsion remover use, but the haze remover lightened the stain considerably.

Products were applied according to the manufacturer's recommended application procedure. The technician noted that the ink remover did have an unpleasant odor.

Alternative System Performance Details

Performance Details from Facility 8

Over the four week demonstration period, this facility reclaimed 48 screens with the Product System Alpha. The screen printing manager reclaimed the screens himself during the

demonstration period. He was willing to experiment with different application techniques to improve the performance of the alternative system.

The printer thought the ink remover performance was satisfactory, but results were inconsistent and the product required extra scrubbing effort to achieve acceptable results. He noted that the ink remover performance was unacceptable on epoxy inks, even with the extra effort. One specific observation was that the ink remover did not stay wet on the screen which made wiping more difficult. Performance improved, however, when he sprayed the product both on the rag and on the screen. After using the ink remover, the printer evaluated each screen and reported that the ink was removed effectively on 62% of the screens.

Typically, this facility uses hot water to start the breakdown of their emulsion. When following the manufacturer's application instructions for the Alpha emulsion remover, which does not require hot water, the printer found the emulsion came off in "strings," instead of dissolving. The stringy, solid mass clogged the drain. To solve this problem, the printer rinsed the screen with hot water before applying the emulsion remover. This additional step took an extra 3 - 5 minutes, but the emulsion remover performance improved.

The haze remover did not sufficiently remove the haze on approximately 20% of the screens. The printer wiped these screens with lacquer thinner (which easily removed the haze) before reusing the screen. The observer confirmed that this supplementary wipe down was necessary and noted that the white rag with lacquer thinner on it turned black as the dark haze was removed from the screen. Overall, the printer felt the alternative haze remover performance was not acceptable.

Data from the printer's product evaluation forms was analyzed to determine if there were any correlations between variations in the product performance and changes in the demonstration conditions (e.g., ink type, emulsion type, screen condition). The printer was asked to evaluate the screen after using each product (ink remover, emulsion remover, and haze remover). In addition, the printer recorded the amount of ink remaining on the screen at the start of reclamation. In reviewing this data, it was found that for screens where the initial ink remaining on the screen was high (i.e., it was not carded off well), there was an ink stain remaining on the screen after emulsion removal (for 100% of the screens in the demonstration). When the initial ink remaining on the screen was recorded as "low", an ink stain remained after emulsion removal for only 33% of the screens. This could indicate that if the screen is effectively carded before ink removal (as the manufacturer recommends), the product performance may improve significantly. Overall, 76% of the screens had an ink stain or stencil stain after using the emulsion remover. After applying the haze remover, 20% of the screens could not be reused because of the remaining haze.

During the four week demonstration, this facility did not notice any change in screen failure rate or any deterioration of the screen mesh. The printer had no problems with print image quality while using Product System Alpha, however, he felt he avoided potential print quality problems by cleaning the screens again with his own ink remover before reusing them.

Performance Details from Facility 13

Overall, this facility was not satisfied with the performance of System Alpha. The alternative system required more time and effort than their standard products and were not as effective in cleaning the screens as their standard products. Because of the extra time required, the facility could not reclaim screens fast enough to keep up with their need to reuse the screens. The screen reclaimer also did not like the strong smells associated with the alternative

system. For these reasons, the printing manager made the decision to discontinue participation in the demonstrations after two weeks. More experimenting with application methods could have lead to improved performance, but this facility did not seem willing to try. The facility contact also mentioned that the reclamation employee was not reliable and that he did not feel confident in the screen reclamation results that were provided. In analyzing the limited data from this facility, the performance of the alternative system did not seem to be affected by ink type, ink color, mesh type, or other demonstration conditions.

The ink remover did not perform as well as their usual product. It removed ink less effectively than was expected and involved more applications and rinsing (which meant more time) to get the ink out of the mesh. The only application changes attempted were to use more product and effort. The added scrubbing was considered a very negative characteristic of the ink remover.

Even at full strength the emulsion remover required more scrubbing and time to remove the emulsion from the screens than their usual product. The alternative emulsion remover did remove the stencil, however, because of the extra time required, the facility discontinued use of the emulsion remover after the first week of demonstrations.

The haze remover did not reduce stains in the mesh as effectively as the facility's usual haze remover. Almost every time the haze remover was used, the facility had to follow with their usual haze remover to get the screen clean enough for reuse. When using their standard product system, this facility needed to use a haze remover for only about 30 percent of their screens. Facility 13 did not experiment with application methods other than extra scrubbing and they stopped using the haze remover after the first week of demonstrations.

No changes were noted in the screens used with the alternative system. Longer-term use of the alternative system may have damaged the screens or reduced screen life because of the excessive scrubbing that was needed with Product System Alpha.

Performance Details from Facility 14

Performance of System Alpha was average at Facility 14. The results are complicated by the fact that three different people were involved in the demonstrations and the two original screen reclamation employees were terminated after about three weeks into the demonstration period. The initial data quality seemed good, but a lot of information was missing from the forms that were submitted from the last week(s) of employment of the terminated employees. The new screen reclaimer may not have followed the same procedures when using the alternative system.

The ink remover worked fairly well, but sometimes had to be reapplied for the screens to be thoroughly cleaned. The product worked particularly well with vinyl inks. The ink remover's performance was improved by applying the ink remover immediately after a print run and letting it sit on the screen for up to a day before it was pressure rinsed off. The manufacturer's directions do not give any recommendations of the soaking time for the ink remover.

The emulsion remover was reported to have worked well at this facility and it worked faster than their usual product. In one case, however, the emulsion remover left a slight green tint in the screens, but this was removed by their usual haze remover.

The initial screen reclaimers felt that the haze remover had average performance, but the final reclaimer felt that it left more of a haze in the mesh than she expected. This later reclaimer only used the product on a few screens and may not have applied the ink remover immediately after the press run which the original employees were doing to improve the performance of the ink remover. This may explain why the new employee thought that more haze than usual was left on the screens. The alternative haze remover and the standard haze remover used at this facility are almost identical chemically. Also, the print quality was very rarely documented by this facility, although it may be safe to assume that problems with print quality would have been reported, if obvious.

The analysis of the data from this facility did not show any correlation between the performance of the alternative system and any variations in ink type, ink color, mesh type, or other demonstration conditions. No side effects on the screens or changes in the screen failure rates were noted during the demonstrations.

Alternative System Performance Table Compiled from Field Sites

The table below highlights the observed performance of the product system and the relevant conditions of the demonstration, as recorded by the printers using the products at the demonstration facilities. In addition to the field demonstration performance data, results of the product tests performed at SPTF are also summarized in this table. More descriptive information on the demonstration facilities is included in the section following the table.

Facility Profiles

General Facility Background for Facility 8

Facility 8 prints labels, nameplates, and graphic overlays, primarily on plastics, but they also do some printing on paper and metals. Their typical run length is 100 sheets, and approximately 75% of their orders are repeat orders. Of the 40 - 50 employees at this facility, approximately 3 are involved in screen reclamation. All printing is done with solvent-based inks; both vinyl and epoxy inks are used. All screens used in the Performance Demonstrations were made of a monoester mesh that was treated with a roughening paste and a degreaser when each screen was initially stretched. Mesh count during the demonstration period ranged from 195 - 330 threads/inch and an indirect stencil was used for all screens. The average screen size used at this facility is 24.5 inches x 31.75 inches (778 in^2) and 10 - 15 screens are reclaimed daily.

Screen Reclamation Area in Facility 8

The screen printing, ink removal, and screen reclamation activities are all done in the same area of the facility. Ink removal is done at the press and screen reclamation is done in a spray booth. The open plant area with high ceilings and overhead fans provide ventilation for the general area. The spray booth has an integrated ventilation fan in the hood. The average temperature during the observer's visit was 68°F (and 40% relative humidity). Rags used for clean up and for ink removal are cleaned under contract by a laundry service. Waste water from the high pressure wash of the emulsion remover and haze remover is filtered at this facility.

Table V-92
On-Site Performance Summary For System Alpha

	System Component	Performance						Demonstration Conditions			
		Avg Drying Time Before Using Product	Average Quantity Applied	Average Cleaning Time	Average Effort Required	Performance for Each System Component	Overall System Performance	Ink type(s)	Emulsion type	Mesh type; Thread count	Average Screen Size
In-field Demonstrations at Volunteer Printing Facilities											
Facility 8	*Ink remover*	10.8 ± 17.6 hrs (n=50)	1.7 ± 0.8 oz. (n=50)	5.9 ± 2.5 mins (n=32)	Moderate	Good on 40% of screens; Fair on 22%; Poor on 38%	• 20% of screens required additional cleaning before reusing them. • Needed to use hot water to get the emulsion to break down.	Solvent-based vinyl and epoxy inks	Indirect photo stencil	Monofilament Polyester; 195 - 330 threads/inch	823 in^2
	Emulsion Remover	1.8 ± 4.2 mins (n=50)	1.0 ± 0.2 oz. (n=50)	9.0 ± 3.9 mins (n=50)	Moderate	With hot water, removed stencil.					
	Haze Remover	1.1 ± 3.5 mins (n=50)	1.0 ± 0.0 oz. (n=39)	7.6 ± 2.5 mins (n=39)	Moderate	Haze was not removed from 20% of screens.					
Facility 13	*Ink Remover*	1.5 ± 3.0 hrs (n=15)	2.5 ± 0.8 oz. (n=15)	15.5 ± 8.0 mins (n=15)	Moderate	Removed the ink but required extra time and effort.	• Most screens had to be re-cleaned with the standard haze remover before the could be reused.	UV-curable and Solvent-based inks	Direct photo stencil	Abraded polyester; 155 - 390 threads/inch	1591 in^2
	Emulsion Remover	5.7 ± 5.8 mins (n=6)	3.9 ± 2.0 oz. (n=7)	11.7 ± 4.5 mins (n=7)	Moderate	Removed stencil, but required extra time and effort.					
	Haze Remover	5.7 ± 4.0 mins (n=3)	1.3 ± 0.5 oz. (n=4)	9.5 ± 2.4 mins (n=4)	Moderate	Did not effectively remove the haze.					

Table V-93

On-Site and Laboratory Performance Summary For System Alpha

		Performance						Demonstration Conditions			
	System Component	**Avg Drying Time Before Using Product**	**Average Quantity Applied**	**Average Cleaning Time**	**Average Effort Required**	**Performance for Each System Component**	**Overall System Performance**	**Ink type(s)**	**Emulsion type**	**Mesh type; Thread count**	**Average Screen Size**
In-field Demonstrations at Volunteer Printing Facilities											
Facility 14	*Ink Remover*	6.6 ± 39.4 hrs (n=37)	4.4 ± 2.0 oz. (n=37)	5.0 mins (n=1)	Low/ Moderate (n=37)	Worked very well with vinyl ink; acceptable on other inks by increasing the soaking time.	• Most screens could be reused, however, some had to be recleaned with other products. • Two reclaimers felt the haze remover performance was acceptable, one did not.	Solvent-based inks	Direct photo stencil	305 - 390 threads/inch	1577 in^2
	Emulsion Remover	19.9 ± 17.9 hrs (n=37)	4.1 ± 0.7 oz. (n=37)	5.0 ± 0.0 mins (n=36)	Low (n=37)	Removed stencil easily.					
	Haze Remover	5.0 ± 19.6 mins (n=37)	4.0 ± 1.0 oz. (n=15)	5.2 ± 0.8 mins (n=16)	Moderate (n=14)	Haze remaining on some screens had to be removed with their standard product.					
Laboratory Testing at SPTF											
SPTF Solvent-based Ink	*Ink Remover*	15 mins	1.5 oz.	3.9 mins	Moderate	Ink dissolved with scrubbing; has bad odor.		Solvent-based	Dual cure direct	Polyester; 255 threads/inch	360 in^2
	Emulsion Remover	24 hours	1.0 oz.	3.7 mins	Moderate	Stencil dissolved completely; medium ink stain.					
	Haze Remover	0 mins	1.0 oz.	9.7 mins	Low	Removed stain completely.					
SPTF UV-curable Ink	*Ink Remover*	15 mins	2.0 oz.	3.5 mins	Low	Ink dissolved well; has bad odor.		UV-curable	Dual cure direct	Polyester; 390 threads/inch	360 in^2
	Emulsion Remover	24 hours	1.0 oz.	2.6 mins	Moderate	Stencil dissolved completely; medium ink stain remaining.					
	Haze Remover	0 mins	1.0 oz.	10.0 mins	Low	Lightened ink stain.					

Current Screen Reclamation Products at Facility 8

Facility 8 uses an ink remover that is a solvent blend of 50% toluene and 50% methyl ethyl ketone, as well as a proprietary blend of propylene glycol ethers (<30%), Stoddard Solvent (a petroleum distillate) (<5%), and d-limonene (<20%). As an emulsion remover, they use a formulation consisting primarily of sodium periodate. Information on their haze remover was not currently available.

Current Screen Reclamation Practices in Facility 8

The screen reclamation process at Facility 8 is described below:

- Ink Remover: Card of excess ink. Pour lacquer thinner from a one-gallon can onto the screen surface with the screen lying flat. Using reusable rags, wipe the ink off the screen. After ink removal at the press, move the screen to the reclamation area.

- Emulsion Remover: Wet the screen with hot water at low pressure. Spray an ink remover on the emulsion side of the screen. Dip a brush into the container of emulsion remover and brush it into both sides of the screen. Rinse both sides of the screen with a high pressure (2500 psi) washer to remove the emulsion.

- Haze Remover: If an ink stain remains after emulsion removal, spray more lacquer thinner onto the screen and rub it in with a scrubber pad. After allowing the lacquer thinner to soak for 1 - 2 minutes, remove the excess ink with a high pressure wash. Haze remover is only applied to approximately 25% of the screens. When needed, apply the haze remover by pouring it from a quart container onto a brush and then rubbing it into the screen. Rinse the screen with the high pressure washer.

General Facility Background for Facility 13

Facility 13 prints store displays, decals, and outdoor signs. Their products are printed on plastics, paper, and metal. A typical run length is 500 - 1000 sheets and approximately 25% of their orders are repeat orders. There are about 70 employees at this facility and 1 - 3 employees are responsible for screen reclamation. The facility uses both UV ink and solvent-based ink. During the Performance Demonstrations they used a direct photo stencil and the screen mesh was an abraded polyester. Mesh counts ranged from 155 - 390 threads/inch. The screen size typically used in this facility is 49 inches x 41 inches, and approximately 20 screens are reclaimed daily.

Screen Reclamation Area in Facility 13

Ink removal and screen reclamation are both done within the screen printing area of the facility where local ventilation is provided. The screen reclamation area is 20 - 50 ft^2 in size. During the observer's visit, the average temperature in the area was 76°F (and 44% relative humidity). Rags used for screen reclamation activities are disposed of as hazardous waste. Waste water from emulsion and haze removal washes is not filtered at this facility.

Current Screen Reclamation Products at Facility 13

Facility 13 uses an ink remover that is a proprietary blend consisting primarily of tripropylene glycol methyl ether. Their emulsion remover consists primarily of sodium periodate. Information on their haze remover was not available.

Current Screen Reclamation Practices in Facility 13

Gloves, eye protection, aprons, and respiratory protection are available for employees during screen reclamation. At Facility 13, screens are reclaimed as follows:

- Ink Remover: Card off the excess ink at press. Dip a soft bristle brush into a five-gallon bucket of ink remover and brush it onto the screen. The dirty ink remover brush is repeatedly dipped into this bucket so the ink remover becomes diluted with ink residue. Pressure wash (1000 psi) the screen.

- Emulsion Remover: Dip a soft bristle brush into the bucket of emulsion remover and rub the product into screen. Apply enough emulsion remover to both sides of the screen to cover the stencil. Pressure wash both sides. Rinse the screen with low pressure water, vacuum it dry, wipe it dry with a disposable rag, and set it in front of an electric fan to dry.

- Haze Remover: Haze remover is used on approximately 50% of the screens, primarily when black, red, and blue inks are used. If haze remover is not needed, apply undiluted ink remover to the screen with a brush after emulsion removal. Rub into both sides of the screen, then pressure wash. Rinse both sides of the screen with low pressure water from a hose. If haze remover is used, do not apply the ink remover after emulsion removal. To apply the haze remover, dip a soft bristle brush into the paste. Rub it into both sides of the stain and wait for 5 - 15 minutes, depending on the severity of the haze. Pressure wash the screen. Vacuum the screen dry, then wipe it with a disposable wipe. Place the screen in front of a fan to dry.

General Facility Background for Facility 14

Facility 14 prints three-dimensional panels, pressure-sensitive labels, and specialty items for advertising. Primarily, they print on plastics and metals, but they also do some printing on paper. A typical run is 100 - 300 sheets and approximately 85% of their orders are repeat orders. Of the approximately 12 employees at this facility, 3 are involved in screen reclamation activities. Several different types of ink are commonly used at Facility 14, including thermal setting, vinyls, and UV-curable, and small amounts of lacquers, enamels, and epoxies. All screens used in the Performance Demonstrations were made of a monofilament polyester and a direct photo stencil emulsion was applied. Mesh count during the demonstration period ranged from 305 - 390 threads/inch. The average screen size used at this facility is 12 ft^2 and approximately 12 screens are reclaimed daily.

Screen Reclamation Area in Facility 14

This facility has two spray booths; one for ink removal and one for emulsion and haze removal. At the ink removal area, the solvent is applied with a pressure sprayer and then filtered and recycled through the system. For ventilation, there is a hood above each spray booth. The average temperature during the observer's visit was 72°F (and 45% relative

humidity). Rags used for screen reclamation are washed by an industrial laundry service. Spent filters are disposed of as hazardous waste. Waste water from the high-pressure wash of the emulsion remover and haze remover is not filtered.

Current Screen Reclamation Products at Facility 14

For ink removal, Facility 14 uses either a product consisting of 99% tripropylene glycol methyl ether, or a proprietary solvent blend sold by a manufacturer not participating in the performance demonstration. MSDS information on the latter product states it contains no hazardous substances, is non-flammable, has no SARA reportable chemicals, and meets California's South Coast Air Quality Management District requirements. Their emulsion remover is a formulation consisting primarily of sodium periodate. For haze removal, they use either an aqueous blend which consists of potassium hydroxide (27%) and tetrahydrofurfuryl alcohol (11%), or an aqueous blend that contains sodium hydroxide (5%) and tetrahydrofurfuryl alcohol (17%).

Current Screen Reclamation Practices in Facility 14

The screen reclamation process at Facility 14 is described below:

- Ink Remover: Card off the excess ink. At the press, spray on the ink remover and wipe off about 95% of the ink with reusable rags. Approximately 2 - 4 rags are used for each screen. Take the screen to the wash out sink and spray on the ink remover solvent from the recirculating tank. With a brush, scrub the ink remover into the screen, then squeegee off the excess solvent and ink. Wipe down with rags. If ink clumps are remaining, spray on more ink remover and wipe the screen again.

- Emulsion Remover: Move the screen to the reclamation area. Spray emulsion remover on the top of the screen and use a scrubber pad to spread it out and work it into the screen. Rinse with a high pressure (2000 psi) wash to remove the emulsion. With a brush, apply a degreaser then rinse with a low pressure (200 psi) wash.

- Haze Remover: After emulsion removal, a haze remover is used only if needed (on approximately 6% of the screens). Apply the haze remover by dipping a brush in the product and rubbing it into the screen. Rinse with a high pressure water spray.

Cost

Table V-94
Method 2: Summary of Cost Analysis for System Alpha

Cost Element Description		Baseline (Traditional System 4)	Alternative System Alpha		
			Facility 8	Facility 13	Facility 14
Facility Characteristics					
Average screen size (in^2)		2,127	823	1,591	1,577
Average # screens/day		6	12.5	20	12
Cost Elements per Screen					
Labor	Time spent applying, scrubbing, and removing reclamation products (min)	24.4	22.5	36.7	15.3
	Cost ($)	5.33	4.92	8.02	3.34
Materials and Equipment	# of rags used	3	1.1	4.1	0
	Cost ($)	0.45	0.17	0.61	0
Reclamation Product Use	Ink Remover Average Volume (oz.)	8.0	1.8	2.5	4.4
	Cost ($)	0.22	0.21	0.31	0.53
	Emulsion Remover Average Volume (oz.)	3.5	1.0	3.9	4.1
	Cost ($)	0.13	<0.01	0.01	0.01
	Haze Remover Average Volume (oz.)	3.0	1.0	1.3	4.0
	Cost ($)	0.12	0.30	0.37	1.18
Hazardous Waste Disposal	Amount (g)	34	31	60	59
	Cost ($)	0.02	0.02	0.04	0.04
Totals					
Total Cost ($/screen)		6.27	5.62	9.36	5.10
	Normalized[a]	6.27	6.79	9.37	5.92
Total Cost ($/year)		9,399	17,574	46,800	15,313
	Normalized[a]	9,399	10,183	14,062	8,886

[a]Normalized values adjust product usage, number of screens cleaned, and number of rags laundered at demonstration facilities to reflect the screen size and number of screens cleaned per day under the baseline scenario. Labor costs, however, are not normalized. Normalization allows a comparison between the baseline and facility results.

Note: For additional information regarding product performance see performance demonstration summaries.

Product System Chi

Formulation

Ink Remover:	Diethylene glycol series ethers
	Propylene glycol series ethers
	N-methyl pyrrolidone
	Ethoxylated nonylphenol
Emulsion Remover:	Sodium periodate
	Water
Haze Remover:	Diethylene glycol series ethers
	Propylene glycol series ethers
	N-methyl pyrrolidone
	Ethoxylated nonylphenol

Occupational Exposure

Table V-95
Occupational Exposure Estimates for Alternative System Chi

System	Inhalation (mg/day)				Dermal (mg/day)	
	I	II	III	IV	Routine	Immersion
Ink Remover						
Diethylene glycol series ethers	0	0	0	0	312	1456
Tripropylene glycol methyl ether	0	0	0	0	858	4000
N-methylpyrrolidone	3	0	0	0.1	312	1460
Ethoxylated nonylphenol	0	0	0	0	78	364
Emulsion Remover (diluted 1:4)						
Sodium periodate	0	0	0	0	16	73
Water	0	0	0	0	1540	7210
Haze Remover						
Diethylene glycol series ethers	0	0	0	0	312	1456
Tripropylene glycol methyl ether	0	0	0	0	858	4000
N-methylpyrrolidone	3	0	0	0	312	1460
Ethoxylated nonylphenol	0	0	0	0	78	364

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry.

Table V-96
Occupational Risk Estimates for Method 2, Alternative System Chi

Name	Hazard Quotient[b]			Margin Of Exposure[a]					
		Dermal		Inhalation		Dermal			
						Routine		Immersion	
	Inhalation	Routine	Immersion	NOAEL[c]	LOAEL[d]	NOAEL	LOAEL	NOAEL	LOAEL
Ink Remover									
Diethylene glycol series ethers	NA	NA	NA	NA	NA	1,800	46	380	9.8
Tripropylene glycol series ethers	NA	NA	NA	NA	NA	NA	NA	NA	NA
N-methylpyrrolidone	NA	NA	NA	3,600	NA	39	NA	8.4	NA
Ethoxylated nonylphenol	NA	NA	NA	NA	NA	NA	NA	NA	NA
Emulsion Remover (diluted 1:4)									
Sodium periodate	NA	NA	NA	NA	NA	NA	NA	NA	NA
Water	NA	NA	NA	NA	NA	NA	NA	NA	NA
Haze Remover									
Diethylene glycol series ethers	NA	NA	NA	NA	NA	1,800	46	380	9.8
Tripropylene glycol series ethers	NA	NA	NA	NA	NA	NA	NA	NA	NA
N-methylpyrrolidone	NA	NA	NA	37	NA	39	NA	8.4	NA
Ethoxylated nonylphenol	NA	NA	NA	NA	NA	NA	NA	NA	NA

[a]Margin of Exposure (MOE) values above 100 for a NOAEL and 1000 for a LOAEL indicate low risk.
[b]Hazard Quotient is the ratio of the estimated chronic dose/exposure level to the Reference Dose (RfD) or the Reference Concentration (RfC). Hazard Quotient values less than 1 imply that adverse effects are very unlikely to occur.
[c]NOAEL means No Observed Adverse Effect Level.
[d]LOAEL means Lowest Observed Adverse Effect Level.

Occupational Risk Conclusions and Observations

Ink Remover and Haze Remover

- Clear concerns exist for chronic dermal exposures to diethylene glycol series ethers used in ink removal based on the calculated margins-of-exposure.

- Concerns exist for developmental toxicity risks from dermal exposures to N-methylpyrrolidone based on the calculated margin-of-exposure. Similar calculations for inhalation exposures to N-methylpyrrolidone indicate very low concern.

- Inhalation exposures to other ink remover components are very low.

- Dermal risks from other ink remover components could not be quantified because of limitations in hazard data, but exposures can be high.

- The haze remover components are identical to the ink removers and present essentially the same risk profile.

Emulsion Removers (All Systems)

- All of the systems that employ an emulsion remover (all systems except Beta) use either a strong oxidizer such as hypochlorite or periodate or a strong base such as sodium hydroxide. The haze removers in Alpha, Epsilon, Gamma, Mu, Omicron, and Theta also contain these compounds. All of these materials present a high concern for skin and eye irritation and tissue damage if workers are exposed in the absence of proper protective clothing. None of the emulsion removers present significant inhalation risks.

Environmental Releases

Table V-97
Environmental Release Estimates in Screen Cleaning Operations
Method 2, Alternative System Chi

System	Release Under Each Scenario (g/day)						
	I			II	III	IV	
	air	water	land	air	air	air	water
Ink Remover							
Diethylene glycol series ethers	0.1	0	138	0	0	0	270
Tripropylene glycol series ethers	0.1	0	381	0	0	0	742
N-methylpyrrolidone	6.8	0	132	0.1	0	0.2	270
Ethoxylated nonylphenol	0	0	35	0	0	0	67
Emulsion Remover (diluted 1:4)							
Sodium periodate	0	6	0	0	0	0	0
Water	0	615	0	0	0	0	0
Haze Remover							
Diethylene glycol series ethers	0.1	104	0	0	0	0	0
Tripropylene glycol series ethers	0.1	286	0	0	0	0	0
N-methylpyrrolidone	6.8	97	0	0.1	0	0	0
Ethoxylated nonylphenol	0	26	0	0	0	0	0

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry

Environmental Release Estimates from Screen Reclamation Processes
Screen Reclamation Method 2, Alternative System Chi

From Ink Removal Operations:

Diethylene glycol series ethers

0.1 g/day to air
270 g/day to water from rags at commercial laundry
138 g/day to landfill

Propylene glycol series ethers

0.1 g/day to air
742 g/day to water from rags at commercial laundry
381 g/day to landfill

N-methyl pyrrolidone
7.1 g/day to air
270 g/day to water at commercial laundry
132 g/day to landfill

Ethoxylated nonylphenol
67 g/day to water from rags at commercial laundry
35 g/day to landfill

From Emulsion Remover:
Sodium periodate
6 g/day to water

From Haze Remover:
Diethylene glycol series ethers
0.1 g/day to air
104 g/day to water

Propylene glycol series ethers
0.1 g/day to air
286 g/day to water

N-methyl pyrrolidone
6.9 g/day to air
97 g/day to water

Ethoxylated nonylphenol
26 g/day to water

Table V-98
Summary of Estimated Daily Environmental Releases from a Hypothetical Facility Using Screen Reclamation Method 2, Alternative System Chi

Substance:	To Air:	To Water:	To Landfill:
Diethylene glycol series ethers	0.2 g/day	104 g/day 270 g/day at laundry	138 g/day
Propylene glycol series ethers	0.2 g/day	286 g/day 742 g/day at laundry	381 g/day
N-methyl pyrrolidone	14 g/day	97 g/day 270 g/day at laundry	132 g/day
Ethoxylated nonylphenol		26 g/day 67 g/day at laundry	35 g/day
Sodium periodate		6 g/day	

Releases to Water from a Single Facility

Table V-99
Estimated Releases to Water from Traditional Formulations from Screen Reclamation at a Single Facility Using Screen Reclamation Method 2, Alternative System Chi

Substance	Amount Released to Water from Facility	Waste water Treatment Removal Efficiency	Amount to Water After Waste water Treatment	Daily Stream Concentration, ug/L[a] for 1000 MLD Receiving Water
Diethylene glycol series ethers	104 g/day 270 g/day at laundry	83 %	18 g/day 46 g/day	2×10^{-2} 4×10^{-2}
Propylene glycol series ethers	286 g/day 742 g/day at laundry	83-97 %	49 g/day 126 g/day	5×10^{-2} 1×10^{-1}
N-methyl pyrrolidone	97 g/day 270 g/day at laundry	97 %	3 g/day 8.1 g/day	3×10^{-3} 8×10^{-3}
Ethoxylated nonylphenol	26 g/day 67 g/day at laundry	100 %	0 g/day 0 g/day	0
Sodium periodate	6 g/day	100 %	0 g/day	0

[a] ug/L is Micrograms per liter, which is parts per billion for a substance in water. MLD is Million liters per day.

Releases to Air from Individual Screen Printing Facilities

Table V-100
Air Release, Concentration and Potential Dose Estimates from a Single Model Facility
Using Screen Reclamation Method 2, Alternative System Chi

Substance	Amount of Releases per day	Highest Average Concentration 100 M away	Annual Potential Dose, mg/year[a]
Diethylene glycol series ethers	0.2 g/day	3.5×10^{-4} ug/m^3	3×10^{-3}
Propylene glycol series ethers	0.2 g/day	3.5×10^{-4} ug/m^3	3×10^{-3}
N-methyl pyrrolidone	14 g/day	2.9×10^{-2} ug/m^3	2×10^{-1}

[a]This estimates doses for people living 100 Meters from the hypothetical facility. The actual number of people who would fall into this range can be determined from census data, if the facility location is known. The model used to calculate concentrations is more completely explained in the Overview by Media-Air Section in Chapter III. To calculate the annual potential dose, the concentration is multiplied by the amount a person will breathe (20 m^3/day) and the number of days per year (365), and the units are converted to mg/year by dividing by 1000.

General Population Risk Conclusions and Observations

- Health risks to the general population from both air and water exposures are very low for Method 2, Product System Chi.

Although air releases were evaluated for only a single facility, it is very unlikely that an analysis of cumulative air releases would lead to different risk conclusions. Examples of general population exposure and risk estimates are shown for Alternative System Chi below. Hazard Quotient values below one indicate very low risk. Margin-of-Exposure (MOE) values above 100 for a NOAEL or above 1000 for a LOAEL indicate very low risk.

Table V-101
Risks from Potential Drinking Water Exposures
Screen Reclamation Method 2, Alternative System Chi

Substance	Daily Stream Concentration, (ug/L)	Daily Dose from Drinking Water (mg/kg)	NOAEL or LOAEL (mg/kg)	MOE - NOAEL or LOAEL/Dose
Diethylene glycol series ethers	5.8×10^{-2}	2×10^{-6}	51 LOAEL	3×10^{7}
Propylene glycol series ethers	1.5×10^{-1}	4×10^{-6}	not available	
N-methyl pyrrolidone	1.1×10^{-2}	3×10^{-7}	175 NOAEL	6×10^{8}
Ethoxylated nonylphenol	0	0	not available	
Sodium periodate	0	0	not available	

Table V-102
Risk Estimates for Ambient Air Releases from a Single Model Facility
Screen Reclamation Method 2, Alternative System Chi

Substance	Highest Avg Concentration 100 M away	Daily Potential Dose, (mg/kg)	NOAEL or LOAEL (mg/kg)	MOE - NOAEL or LOAEL/ Dose
Diethylene glycol series ethers	3.5×10^{-4} ug/m^3	1×10^{-7}	51 LOAEL	5×10^{8}
Propylene glycol series ethers	3.5×10^{-4} ug/m^3	1×10^{-7}	not available	
N-methyl pyrrolidone	2.9×10^{-2} ug/m^3	8×10^{-6}	175 NOAEL	2×10^{7}

Ecological Risks From Water Releases Screen Reclamation Chemicals

- None of the single facility releases of Method 2, Product System Chi reach an ecotoxicity concern concentration.

Performance

General Summary of Product System Chi Performance, and Related Variables

This product system consisted of an ink remover and an emulsion remover. In place of a separate haze remover product, the ink remover was reapplied to remove haze. A degreaser accompanied this product system and was used by the facilities, however, detailed information on the performance of the degreaser is not included in the scope of this project. The performance of the product system was demonstrated at Facilities 3 and 21. Facility 3 prints decals and vacuum formed sheets; Facility 21 prints decals for glass and ceramics. During the

four week demonstration period, Facility 3 reclaimed 47 screens and Facility 21 reclaimed 48 screens. Both facilities used only solvent-based inks during the demonstrations.

The ink remover performance was considered satisfactory by Facility 3 and was considered good at Facility 21. At Facility 3, the alternative ink remover took longer to solubilize the ink and required more physical effort than their usual product. Facility 21 reported that the Product System Chi ink remover worked very well on most of their inks, but the alternative ink remover did not work as well with cover/flux ink or clear cover coats. They have similar problems with their standard ink remover on the cover/flux and clear coats. They also found additional scrubbing was needed when using the alternative ink remover on very coarse (low mesh count) screens. Overall, they described the ink remover performance as good, but not quite as good as their standard product.

The two facilities were both quite pleased with the performance of the emulsion remover. Facility 3 reported the performance was as good as their standard product. Facility 21 thought that the emulsion remover worked much better than their usual product. Although it worked well on both direct and capillary film emulsions, Facility 21 found a little more effort was required to remove the capillary film emulsions than the direct emulsions.

This system did not include a haze remover. Instead, the manufacturer recommended that the ink remover be used a second time as a haze remover. After using the ink remover following removal of the emulsion, Facility 3 reported that an image was still left on the screen and that, when used for haze removal, the ink remover did not perform as well as their usual haze remover. At Facility 21, a haze remover was needed on only one screen of the 48 screens reclaimed.

Alternative System Chi Profile

The manufacturer recommends applying Product System Chi as follows:

- Ink Remover: Card up the excess ink to remove as much as possible from the screen. Bring the screen to the reclaiming area and apply the ink remover as soon as possible, even if the screen is not to be cleaned until later. Use a spray bottle and apply the product to both sides of the screen, using ample product to coat the inked areas completely. Thoroughly brush the ink remover into the screen, paying close attention to print areas and heavy ink spots. Allow as much time as possible for the product to dissolve the ink. If more product is needed to loosen the ink, apply it in the needed areas and brush again. Pressure rinse the screen, beginning with the well side, from the bottom of the screen to the top. Turn the screen around and repeat the pressure rinse from bottom to top.

- Emulsion Remover: Dilute 1 part emulsion remover in 4 - 5 parts water. Spray the emulsion remover onto the wet screen and allow enough time for the product to completely dissolve the emulsion. Use a brush to loosen the emulsion on the entire screen. Pressure wash the screen on both sides, rinsing from the top to the bottom. At SPTF, a 1000 psi pressure washer was used.

- Additional Stain Removal Step: If stains remain in the screen, allow the screen to dry and repeat the application procedure for the ink remover and pressure rinse.

Alternative System Performance at SPTF

Product System Chi was tested at SPTF on three screens (one with a solvent-based ink, one with a UV-curable ink, and one with a water-based ink). The ink remover performance varied, depending on the type of ink used. Performance of the emulsion remover and the haze remover was consistent for all three screens. All products were applied according to the manufacturer's recommended application procedure.

On the screen with the solvent-based ink, there was considerable ink residue remaining after spraying the screen with product, scrubbing with a brush, and rinsing with a high pressure wash. The technician also noticed that the stencil was beginning to peel off. After repeating the ink remover application process, the ink residue was still present and about half of the stencil had been removed. The ink dissolved more easily on the screen with UV ink, however, after using the ink remover, a gray haze remained on the screen, but there was no noticeable ink residue and the stencil was intact. On the screen with the water-based ink, the product dissolved the ink fairly well, however, a light ink residue remained on the screen and the stencil began to peel off.

The emulsion remover easily dissolved the stencil with only light scrubbing on all three screens, leaving no emulsion residue behind. On the screen with the solvent-based ink, the heavy ink residue was still present after using the emulsion remover. When additional ink remover was applied (used instead of a haze remover in this product system), it removed the residue and lightened the stain. After using the emulsion remover on the screen with UV ink, a moderate to heavy ink stain remained. The reapplication of the ink remover lightened this stain considerably. On the screen with water-based ink, the ink residue persisted in some areas and there was a heavy ink stain on the screen after using the emulsion remover. An additional application of ink remover lightened the stain, but did not remove it.

Alternative System Performance Details

Performance Details from Facility 3

Throughout the performance demonstration period, the facility contact was asked about the performance of the components of Product System Chi. He was generally pleased with the performance of the ink remover and emulsion remover, although the ink remover took longer to solubilize the inks than their standard product in some cases. when used as a haze remover, the ink remover usually did not remove the ghost image from the screen. Overall, the facility contact remarked that he did not think that System Chi would be a viable long-term alternative reclaiming system for his plant.

The ink remover worked acceptably on all screens, although it was somewhat slower to dissolve the inks than the facility's regular ink remover. The printer tried using the product to clean the squeegee and flood bar on the press after printing runs, but found that it was slow to break down the ink and left an oily film. After several cycles of printing and reclaiming with the demonstration screens, a noticeable ink haze began to build up in the screens, indicating that the ink remover was not removing all the ink from the mesh. The buildup was not enough to prevent successful printing of regular jobs with the screens, but the facility contact felt that the performance of the screens on a transparent ink image or a flood coat would be unacceptable. There were some variations in the time it took to remove the ink, ranging from 2 to 12 minutes. However, the recorded data does not show any correlation between the ink remover time and any of the variable screen conditions, such as ink color or number of impressions.

The emulsion remover worked well, with no notable variations in performance among the screens used for the demonstration period. The facility contact did not think the product was chemically different from what he had been using previously.

This system did not include a haze remover; instead the manufacturer recommended applying the ink remover again to remove any remaining haze. At Facility 3, the ink remover did not satisfactorily remove the haze. Ghost images continued to build on the screens throughout the demonstration period. The facility normally uses two haze remover products. One haze remover is a milder chemical, which leaves a small amount of ink haze in the screens. This product is used by itself on a regular basis until ghost images in the screen become unacceptable. The other haze remover, which is a stronger chemical, is then used to de-haze the screen to a baseline clean state, after which the screen reclaimer returns to the milder chemical for as many reclaimings as possible. The facility contact remarked that the performance of the alternative haze remover is similar to their "milder" regular haze remover, except that the ink haze built up faster using the alternative product.

Product System Chi did not appear to cause screen failure, or have any noticeable permanent effects on the screens or frames. The three squirt bottles shipped with the products started leaking around the triggers during the first week of the demonstration, and had to be replaced. It is not known if this is an effect of the products or not.

Performance Details from Facility 21

This facility was generally pleased with the performance of System Chi. Currently, the facility uses an automatic screen washer, which cleans the screens in a closed system that recycles the solvent. This was a very organized facility and the quality of the data received was probably quite high. They thoroughly documented the demonstrations and only one screen reclaimer was involved in the demonstrations. The production manager was responsible for monitoring the future print quality on screens reclaimed with the alternative system. He paid very careful attention to screen conditions and would have noticed any deleterious effects of the alternative system. No changes in the screen mesh or print quality were noted during the demonstrations.

The ink remover worked well, however it was not as efficient as their standard product. The facility particularly liked the ink remover's performance with metallic inks. When used on screens with cover (flux) coats or with other clear ink coats, the ink remover did not work well, although the facility has similar problems with their current ink remover. Added scrubbing was needed to remove ink from very coarse (low mesh count) screens. Ink color and number of impressions did not seem to affect ink remover performance.

The emulsion remover worked much better ("excellent") than the product they had been using. Although it worked very well on both emulsion types, the emulsion remover required a little more effort to remove capillary film emulsion than direct emulsion.

For Product System Chi, a second application of the ink remover was used in place of a haze remover as needed. At this facility, a haze remover was needed on only one screen. On that screen, a ghost image remained in the mesh after using the ink remover one time. After reapplying the ink remover two more times, the image was lightened enough to reuse the screen. Normally, this facility does not use a haze remover.

Alternative System Performance Table Compiled from Field Sites

The following table highlights the observed performance of the product system and the relevant conditions of the demonstration, as recorded by the printers using the products at the demonstration facilities. In addition to the field demonstration performance data, results of the product tests performed at SPTF are also summarized in this table. More descriptive information on the demonstration facilities is included in the section following the table.

Facility Profiles

General Facility Background for Facility 3

Facility 3 prints decals and vacuum formed sheets on plastics and paper. A typical run is 250 sheets, and 71% of their orders are repeat orders. Of the approximately 40 employees at this facility, 1 - 3 are involved in screen reclamation. All printing is done with solvent-based inks. Screens used in the Performance Demonstrations were polyester or monoester/polyester with a mesh count of 180 - 370 threads/inch. The facility used a dual cure emulsion. The average screen size at this facility is 15 ft^2 and approximately 15 screens are reclaimed daily.

Screen Reclamation Area in Facility 3

Ink removal is done at the press where local ventilation is provided. The screen reclamation room is approximately 150 ft^2, with a large spray booth built into one wall, and is also ventilated with a local system. The average temperature during the observer's visit was 64°F (and 39% relative humidity). Rags used for clean up and for ink removal are cleaned by a laundry service. Waste water from the high-pressure wash of the emulsion remover and haze remover is not recycled or filtered at this facility.

Current Screen Reclamation Products at Facility 3

Facility 3 uses a proprietary solvent blend for ink removal, which consists of n-butyl acetate (81%) and toluene (19%). For emulsion removal, they use a formulation consisting of 100% sodium periodate. They use two different haze removal products at this facility. One product is a proprietary solvent blend which contains at least sodium hydroxide and cyclohexanone. Their other haze removal product, sold by a manufacturer who is not participating in the performance demonstration, contains no carcinogens, no ingredients with TLV or PELs, and no petroleum derivatives, according to the MSDS.

Current Screen Reclamation Practices in Facility 3

Using their standard products, screens are reclaimed as follows:

- Ink Remover: Card off the excess ink. Pour the ink remover onto the screen and wipe with rags until clean. Approximately 2 - 4 rags are used for each screen. Gloves and eye protection are worn during ink removal.

- Emulsion Remover: Dip a scrubber pad into the container of emulsion remover. Scrub both sides of the screen. Using a high pressure wash (1200 psi), rinse the screen. Gloves, eye protection, respiratory protection, and ear protection are available to employees for emulsion removal and haze removal.

Table V-103
On-Site Performance Summary For System Chi

	System Component	Performance						Demonstration Conditions			
		Avg Drying Time Before Using Product	Average Quantity Applied	Average Cleaning Time	Average Effort Required	Performance for Each System Component	Overall System Performance	Ink type(s)	Emulsion type	Mesh type; Thread count	Average Screen Size
In-field Demonstrations at Volunteer Printing Facilities											
Facility 3	*Ink remover*	7.2 ± 3.6 mins (n=50)	1.1 ± 0.4 oz. (n=50)	6.6 ± 2.3 mins (n=50)	Moderate	Dissolved ink with extra effort.	• All screens could be reused. • Printer was concerned with effect of possible haze build up over time.	Solvent-based	Dual Cure	Polyester, no treatment; 180 - 370 threads/inch	1977 in^2
	Emulsion Remover	15.1 ± 21.7 hrs (n=50)	2.1 ± 0.4 oz. (n=50)	2.9 ± 0.3 mins (n=50)	Low	Removed stencil easily.					
	Haze Remover	0.2 ± 0.2 mins (n=47)	2.1 ± 0.3 oz. (n=47)	2.9 ± 0.3 mins (n=47)	Low	Ghost images built up.					
Facility 21	*Ink Remover*	7.6 ± 12.6 hrs (n=51)	1.1 ± 0.3 oz. (n=48)	2.0 ± 1.5 mins (n=47)	Low	Dissolved ink with extra effort.	• All screens could be reused for future print jobs.	Solvent-based	Capillary film and Direct photo stencil	Polyester, half-calendared or low elongation threads; 60 - 390 threads/inch	1088 in^2
	Emulsion Remover	4.7 ± 8.6 mins (n=51)	1.5 ± 1.4 oz. (n=48)	2.5 ± 2.2 mins (n=48)	Low	Removed stencil easily.	• Haze removal step rarely needed.				
	Haze Remover	15.0 mins (n=1)	2.0 oz. (n=1)	3.5 ± 0.7 mins (n=2)	Moderate	Several applications needed to remove haze.	• Worked well on metallic inks.				

Table V-104
Laboratory Testing Performance Summary For System Chi

	System Component	Performance						Demonstration Conditions			
		Avg Drying Time Before Using Product	Average Quantity Applied	Average Cleaning Time	Average Effort Required	Performance for Each System Component	Overall System Performance	Ink type(s)	Emulsion type	Mesh type; Thread count	Average Screen Size
Laboratory Testing at SPTF											
SPTF Solvent-based Ink	*Ink Remover*	15 mins	not recorded	7.5 mins	Moderate	Heavy ink residue. Started to remove stencil.		Solvent-based	Dual cure direct	Polyester; 255 threads/inch	360 in^2
	Emulsion Remover	24 hours	1.0 oz.	3.3 mins	Low	Dissolved stencil easily. Heavy ink residue remaining.					
	Haze Remover	0 mins	2.5 oz.	4.7 mins	Low	Lightened ink stain.					
SPTF UV-curable Ink	*Ink Remover*	15 mins	1.0 oz.	4.0 mins	Low	Dissolved the ink but left a grey haze over entire screen.		UV-curable	Dual cure direct	Polyester; 390 threads/inch	360 in^2
	Emulsion Remover	24 hours	1.0 oz.	4.0 mins	Low	Dissolved stencil easily.					
	Haze Remover	0 mins	1.0 oz.	4.0 mins	Low	Lightened the ink stain.					
SPTF Water-based Ink	*Ink Remover*	15 mins	2.0 oz.	4.5 mins	Moderate	Light ink residue. Stencil started peeling.		Water-based	Dual cure direct	Polyester; 255 threads/inch	360 in^2
	Emulsion Remover	24 hours	1.5 oz.	4.1 mins	Low	Dissolved stencil easily. Heavy ink stain and light residue.					
	Haze Remover	0 mins	1.5 oz.	3.3 mins	Low	Lightened ink stain.					

- Haze Remover: The facility uses two haze remover products. Apply the first product to every screen. Spray the product onto the screen, brush it into the stained area on both sides and rinse with a high pressure wash. The second product is a stronger chemical and is used only when the ghost images in the screen become unacceptable (approximately 15% of the reclamations). To apply this haze remover, dip a scrubber pad into the container of product and scrub both sides of the screen. Rinse with a high pressure wash.

General Facility Background for Facility 21

Facility 21 prints decals for glass and ceramics. Their typical run length is 1000 sheets and approximately 50% of their orders are repeat orders. There are approximately 15 -20 employees at this facility, and 1 - 3 people are responsible for screen reclamation. During the Performance Demonstration, this facility used solvent-based inks, a capillary film emulsion, and screens with mesh counts that ranged from 60 - 390 threads/inch. Their average screen size is 3 feet x 3 feet and 20 - 25 screens are reclaimed daily.

Screen Reclamation Area in Facility 21

Ink removal and screen reclamation are both done in the screen reclamation room, which is approximately 150 ft^2 in size. A fan in the hood above the reclamation sink provides ventilation for the area. During the observer's visit, the average temperature in the room was 68°F (and 56% relative humidity). Ink remover is recycled off-site, and the recycled product is returned to the facility for in-house use. Reusable shop rags are cleaned by an industrial laundry service. Waste water from the washes of the emulsion remover and haze remover is not recycled or filtered at this facility.

Current Screen Reclamation Products at Facility 21

The standard ink remover at Facility 21 is a proprietary product, sold by a manufacturer not participating in the performance demonstration, that contains no carcinogens, no ingredients with TLV or PELs, and no petroleum derivatives, according to the MSDS. Their emulsion remover contains primarily sodium periodate. Their standard haze remover is a proprietary solvent blend which includes sodium hydroxide and cyclohexanone.

Current Screen Reclamation Practices in Facility 21

During the screen reclamation process at Facility 21, personal protective equipment available to the employees includes gloves, eye protection, aprons, respiratory protection, ear protection, and barrier cream. Screens are reclaimed as follows:

- Ink Remover: At the press, card off excess ink and wipe the screen with the in-process ink remover. Bring the screen to the screen reclamation room. Spray on the ink remover and rub it into the screen with a scrubber pad. Remove the ink by running a squeegee over the screen. Wipe off both sides of the screen with a reusable rag. One or two rags are used on each screen. Move the screen to the sink and rinse both sides of the screen with a hose to remove the blockout.

- Emulsion Remover: Spray both sides of the screen with the emulsion remover. Let sit until the emulsion starts to dissolve. Rub the stencil with a reusable rag. Rinse the screen with a high pressure wash (1000 psi).

- Haze Remover: A haze remover is rarely used (on approximately 1% of the screens reclaimed). Instead, the ink remover is reapplied to about 50% of the screens. For the remaining screens, reclamation is considered complete after the emulsion removal step. When haze remover is used, apply as follows: dip a brush in the product container, rub the haze remover into the screen, and rinse with a pressure wash.

Cost

Table V-105
Method 2: Summary of Cost Analysis for Alternative System Chi

Cost Element Description		Baseline (Traditional System 4)	Alternative System Chi	
			Facility 3	Facility 21
Facility Characteristics				
Average screen size (in^2)		2,127	1,977	1,088
Average # screens/day		6	15	23
Cost Elements per Screen				
Labor	Time spent applying, scrubbing, and removing reclamation products (min)	24.4	12.3	8.0
	Cost ($)	5.33	2.69	1.74
Materials and Equipment	# of rags used	3	1.2	1.2
	Cost ($)	0.45	0.18	0.19
Reclamation Product Use	Ink Remover Average Volume (oz.)	8.0	1.1	1.1
	Cost ($)	0.22	0.21	0.21
	Emulsion Remover Average Volume (oz.)	3.5	2.1	1.5
	Cost ($)	0.13	0.07	0.05
	Haze Remover Average Volume (oz.)	3.0	2.1	2.0
	Cost ($)	0.12	0.39	0.37
Hazardous Waste Disposal	Amount (g)	34	0	0
	Cost ($)	0.02	0	0
Totals				
Total Cost ($/screen)		6.27	3.55	2.56
Normalized[a]		6.27	3.89	3.25
Total Cost ($/year)		9,399	13,312	14,413
Normalized[a]		9,399	5,829	4,879

[a]Normalized values adjust product usage, number of screens cleaned, and number of rags laundered at demonstration facilities to reflect the screen size and number of screens cleaned per day under the baseline scenario. Labor costs, however, are not normalized. Normalization allows a comparison between the baseline and facility results.
Note: For additional information regarding product performance see performance demonstration summaries.

Product System Delta

Formulation

Ink Remover: Dibasic esters
Propylene glycol series ethers
Ethoxylated nonylphenol

Emulsion Remover: Sodium periodate
Water

Haze Remover: Dibasic esters
Propylene glycol series ethers
Ethoxylated nonylphenol

Occupational Exposure

Table V-106
Occupational Exposure Estimates for Alternative System Delta

System	Inhalation (mg/day)				Dermal (mg/day)	
	I	II	III	IV	Routine	Immersion
Ink Remover						
Dibasic esters	2	0	0	0.1	702	3280
Propylene glycol series ethers	0	0	0	0	780	3640
Ethoxylated nonylphenol	0	0	0	0	78	364
Emulsion Remover (diluted 1:1)						
Sodium periodate	0	0	0	0	39	182
Water	0	0	0	0	1520	7100
Haze Remover						
Dibasic esters	2	0	0	0	702	3280
Propylene glycol series ethers	0	0	0	0	780	3640
Ethoxylated nonylphenol	0	0	0	0	78	364

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry

Occupational Risk Estimates

Quantitative risk estimates could not be determined for this system due to insufficient data. See risk conclusions for areas of concern for this system.

Occupational Risk Conclusions and Observations

Ink Remover and Haze Remover

- Although no risks could be quantified because of limitations in hazard data, relatively high dermal exposures to ink remover and haze remover components could occur.

- Inhalation exposures to all components are very low.

Emulsion Removers (All Systems)

- All of the systems that employ an emulsion remover use either a strong oxidizer such as hypochlorite or periodate or a strong base such as sodium hydroxide. The haze removers in Alpha, Epsilon, Gamma, Mu, Omicron, and Theta also contain these compounds. All of these materials present a high concern for skin and eye irritation and tissue damage if workers are exposed in the absence of proper protective clothing. None of the emulsion removers present significant inhalation risks.

Environmental Releases

Table V-107
Environmental Release Estimates in Screen Cleaning Operations
Method 2, Delta System

System	Release Under Each Scenario (g/day)						
	I			II	III	IV	
	air	water	land	air	air	air	water
Ink Remover							
Dibasic esters	3.7	0	319	0	0	0.2	608
Tripropylene glycol series ethers	0.1	0	359	0	0	0	675
Ethoxylated nonylphenol	0	0	36	0	0	0	67
Emulsion Remover (diluted 1:1)							
Sodium periodate	0	16	0	0	0	0	0
Water	0	605	0	0	0	0	0
Haze Remover							
Dibasic esters	3.7	239	00	00	00	00	00
Tripropylene glycol series ethers	0.1	269	0	0	0	0	0
Ethoxylated nonylphenol	0	27	0	0	0	0	0

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry

Environmental Release Estimates from Screen Reclamation Processes
Screen Reclamation Method 2, Alternative System Delta

From Ink Removal Operations:

Dibasic esters

3.9 g/day to air
608 g/day to water from rags at commercial laundry
319 g/day to landfill

Propylene glycol series ethers

0.1 g/day to air
675 g/day to water from rags at commercial laundry
359 g/day to landfill

Ethoxylated nonylphenol

67 g/day to water from rags at commercial laundry
36 g/day to landfill

From Emulsion Remover:
Sodium periodate
16 g/day to water

From Haze Remover:
Dibasic esters
3.7 g/day to air
239 g/day to water

Propylene glycol series ethers
0.1 g/day to air
269 g/day to water

Ethoxylated nonylphenol
27 g/day to water

Table V-108
Summary of Estimated Daily Environmental Releases from a Hypothetical Facility Using Screen Reclamation Method 2, Alternative System Delta

Substance:	To Air:	To Water:	To Landfill:
Dibasic esters	7.6 g/day	239 g/day 608 g/day at laundry	319 g/day
Propylene glycol series ethers	0.2 g/day	269 g/day 675 g/day at laundry	359 g/day
Ethoxylated nonylphenol		27 g/day 67 g/day at laundry	36 g/day
Sodium periodate		16 g/day	

Releases to Water from a Single Facility

Table V-109
Estimated Releases to Water from Traditional Formulations from Screen Reclamation at a Single Facility Using Screen Reclamation Method 2, Alternative System Delta

Substance	Amount Released to Water from Facility	Waste water Treatment Removal Efficiency	Amount to Water After Waste water Treatment	Daily Stream Concentration, ug/L[a] for 1000 MLD Receiving Water
Dibasic esters	239 g/day 608 g/day at laundry	84-97 %	22 g/day 55.1 g/day	2×10^{-2} 6×10^{-2}
Propylene glycol series ethers	269 g/day 675 g/day at laundry	83-97 %	35 g/day 88 g/day	3×10^{-2} 9×10^{-2}
Ethoxylated nonylphenol	27 g/day 67 g/day at laundry	100 %	0	0
Sodium Periodate	16 g/day	100 %	0	0

[a] ug/L is Micrograms per liter, which is parts per billion for a substance in water. MLD is Million liters per day.

Releases to Air from Individual Screen Printing Facilities

Table V-110
Air Release, Concentration and Potential Dose Estimates from a Single Model Facility Using Screen Reclamation Method 2, Alternative System Delta

Substance	Amount of Releases per day	Highest Average Concentration 100 M away	Annual Potential Dose, mg/year[a]
Dibasic esters	7.6 g/day	1.6×10^{-2} ug/m^3	1.1×10^{-1}
Propylene glycol series ethers	0.2 g/day	3.5×10^{-4} ug/m^3	3×10^{-3}

[a]This estimates doses for people living 100 Meters from the hypothetical facility. The actual number of people who would fall into this range can be determined from census data, if the facility location is known. The model used to calculate concentrations is more completely explained in the Overview by Media-Air Section in Chapter III. To calculate the annual potential dose, the concentration is multiplied by the amount a person will breathe (20 m^3/day) and the number of days per year (365), and the units are converted to mg/year by dividing by 1000.

General Population Risk Conclusions and Observations

- Health risks to the general population from both air and water exposures are very low for Method 2, Product System Delta.

Although air releases were evaluated for only a single facility, it is very unlikely that an analysis of cumulative air releases would lead to different risk conclusions. Examples of general population exposure and risk estimates are shown for Method 2, Traditional System 1 in Methods 1 and 2 and Alternative System Chi in Method 2; please reference these sections as illustrative examples. Hazard Quotient values below one indicate very low risk. Margin-of-Exposure (MOE) values above 100 for a NOAEL or above 1000 for a LOAEL indicate very low risk.

Ecological Risks From Water Releases Of Screen Reclamation Chemicals

- None of the single facility releases of Method 2, Product System Delta reach an ecotoxicity concern concentration.

Performance

General Summary of Product System Delta Performance, and Related Variables

The performance of the Alternative System Delta was demonstrated at Facilities 10 and 11, who both used UV-cured inks. This product system consisted of an ink remover and an emulsion remover. In place of a separate haze remover product, the manufacturer recommended that the ink remover be reapplied to remove haze. A degreaser accompanied this product system and was used by the facilities, however, detailed information on the performance of the degreaser is not included in the scope of this project. Facility 10 prints store displays and Facility 11 prints vehicle markings and pressure sensitive decals. During the demonstrations, Facility 10 reclaimed 17 screens over a 3 week period and Facility 11 reclaimed 31 screens over 4 weeks.

At Facility 10, the ink remover removed the ink efficiently on 67% of the screens. On the other 33% of the screens, a slight ink residue remained on the screen after using the ink remover. Overall, the performance of the ink remover was considered fair, however, it required extra effort and it had a strong smell and the screen reclamation employees thought it gave them headaches. Facility 11 had better results and they considered the performance of the ink remover to be very good. It consistently and efficiently removed the ink from their screens under most conditions.

The emulsion remover worked very well and both facilities expressed an interest in continuing to use the product after the demonstrations were complete. Facility 10 found the product worked best when diluted at one part emulsion remover to one part water. Facility 11 used a dilution of one part emulsion remover to three parts water.

Neither facility regularly documented the performance of the ink remover used in a second application as a haze remover. Facility 10 used it a few times and found that it did not remove the haze satisfactorily. On subsequent screens where a haze remover was needed, they used their standard haze remover product. At Facility 11, the ink remover and emulsion remover cleaned the screen well enough that a haze removal step was not needed.

Alternative System Delta Profile

The manufacturer recommends applying Alternative System Delta as follows:

- Ink Remover Card up the excess ink to remove as much as possible from the screen. Apply the ink remover as soon as possible after the press run, even if the screen is not to be cleaned until later. Use a spray bottle and apply the product to both sides of the screen, using ample product to coat the inked areas completely. Thoroughly brush the ink remover into the screen, paying close attention to print areas and heavy ink spots. Allow as much time as possible for the product to dissolve the ink. If more product is needed to loosen the ink, apply it in the needed areas and brush again. Pressure rinse the screen, beginning with the well side, from the bottom of the screen to the top. Turn the screen around and repeat the pressure rinse from bottom to top. At SPTF, a 1000 psi pressure washer was used.

- Emulsion Remover Dilute 1 part emulsion remover in 4 - 5 parts water. Spray the emulsion remover onto the wet screen and allow enough time for the product to completely dissolve the emulsion. Use a brush to loosen the emulsion on the entire screen. Pressure wash the screen on both sides, rinsing from the top to the bottom.

- Additional Stain Removal Step If stains remain in the screen, allow the screen to dry and repeat the application procedure for the ink remover and pressure rinse.

Alternative System Performance at SPTF

Product System Delta was tested at SPTF on three screens (one with a solvent-based ink, one with a UV-curable ink, and one with a water-based ink). The ink remover performance varied, depending on the type of ink used. Performance of the emulsion remover and the haze remover was more consistent for the three screens. All products were applied according to the manufacturer's recommended application procedure.

On the screen with the solvent-based ink, there was some ink residue remaining after applying the ink remover. While scrubbing the screen to remove the ink, approximately half of the emulsion was also removed. The results were similar on the screen with UV ink. Moderate ink residue remained on the screen and some of the stencil in the half-tone area peeled off while scrubbing. On the third screen (water-based ink), the ink residue was still heavy after applying the ink remover. Again, some of the stencil was lost while brushing in the ink remover. For this screen (water-based ink), the technician repeated the ink remover application process, which removed most of the residue, but also removed most of the stencil. Because two applications of ink remover were needed, the quantity of ink remover and the time it took to clean the screen were about twice as much for the screen with water-based ink.

The emulsion remover easily dissolved the stencil on all three screens, leaving no emulsion residue behind. On the screen with the solvent-based ink, a heavy ink residue was still present after using the emulsion remover. The haze remover, which is an additional application of the ink remover in this product system, was then applied. It removed the residue, but an ink stain remained on the screen. Some ink residue remained on the screen with UV ink after using the emulsion remover, but the haze remover (a second application of ink remover) removed the residue, leaving a moderate ink stain. The emulsion remover worked best on the screen with water-based ink. The stencil dissolved easily with only light scrubbing. A small amount of ink residue remained, as well as moderate ink stain. A reapplication of the ink remover removed the residue, but did not lighten the stain significantly.

Alternative System Performance Details

Performance Details from Facility 10

System Delta had average success at this facility. The ink remover performance was acceptable and the emulsion remover worked very well. A second application of the ink remover as a haze remover did not remove the haze from the screens, therefore the facility used their standard haze remover when needed. After three weeks, the print manager decided they did not want to continue their participation in the performance demonstrations because their standard ink remover and haze remover worked better than the alternative system.

The ink remover's effectiveness was considered average at this facility. Prior to the performance demonstrations, the facility was using an ink remover that had a chemical composition very similar to that of the ink remover supplied in Product System Delta. This facility cards off excess ink and also wipes the screen with a rag so there is very little ink left on the screen when the ink remover product is applied. The reclaimers did not like using this product because of its strong smell and many of the employees felt that the ink remover gave them headaches. Facility 10 did not use a pressure wash to remove the ink, as recommended by the manufacturer. Instead, they wiped off the dissolved ink with reusable rags.

The emulsion remover was very effective when diluted one part emulsion remover to one part water (the manufacturer recommends diluting with 4 - 5 parts water). At this dilution level, the reclaimers were very pleased with its performance and wanted to continue using the product. This facility also liked the emulsion remover's lack of odor. When they first started using this emulsion remover, they diluted it in 4 parts water, as recommended. They found it did not work as well as their usual emulsion remover, so they tried diluting it in two parts water, and found it worked best when one part emulsion remover was diluted in one part water.

The facility infrequently documented the performance of the ink remover as a haze remover when applied a second time. After only a few screens, they felt that their usual haze remover worked much more effectively. On most of the screens, no haze remover was needed, however, when it was required, Facility 10 used their standard haze remover after using the alternative ink remover and emulsion remover.

Facility 10 did not notice that the alternative system performed differently with screen conditions. The data did not show any correlations between screen conditions (e.g., ink color, ink drying time) and indicators of performance (e.g., time to clean, quantity of product used). The printer felt that screens that sat around for days before reclamation were more difficult to clean than screens cleaned immediately after the print run ended.

No changes were noticed in screen wear or in screen failure rates. Print image quality was good, however, since they were using their own haze remover, it is difficult to determine if there would have been any changes to the print image quality as a result of using only the alternative system.

Performance Details from Facility 11

Overall this facility felt that System Delta worked well. The printing manager felt that if the alternative system is actually safer for his workers or for the environment, then he would like to use this product system at his facility. The application procedures for the alternative

system closely resembled their usual reclamation procedures and this similarity may have made Facility 11 more receptive to using System Delta.

The ink remover effectively removed the ink from the screens in all instances. A UV-cured ink system was used with all screens in the demonstrations. The printer commented that the ink remover was "less effective" when the ink dried on the screen for a long time. The data from this facility shows that screens where the reclaimer took 5 minutes or less to remove the ink had dried an average of 2.7 hours prior to ink removal. Screens where the ink removal step took longer than 5 minutes had dried an average of 21.6 hours. By applying the ink remover immediately after the press run, as recommended by the manufacturer, it appears time spent on ink removal could possibly be reduced. Facility 11 followed the manufacturers instructions and used a pressure wash to remove the ink from the screen. Before the ink removal step, most of the ink was carded off the screen.

The emulsion remover worked very well for this facility at a variety of concentrations. The initial reclamations were performed without diluting the emulsion remover and performance was very good. After trying several different dilution ratios, they found a mix of one part product to three parts water worked very well at this facility.

After applying the ink remover and emulsion remover, the screens were clean enough that a haze removing step was unnecessary. Even without a haze remover step during the reclamation process, the print quality was excellent. When using their usual products, this facility attempts to minimize their use of haze remover; they only uses haze remover to clean a screen when there is a haze that has built up over time or when much adhesive remains in the screen.

The same screen reclaimer performed all of the demonstrations and evaluated the printing performance of the reclaimed screens. However, the reclaimer was moved to the position of printer during the demonstrations period. Undoubtedly, this change reduced the number of screens that were reclaimed with the alternative system and the forms were also lacking in details. Since he was pleased with the alternative system performance, he did not take the time to record many specific details.

Overall the use of System Delta did not produce any deleterious effects of the screen mesh or subsequent print image quality. The printing supervisor noted that the alternative system may be reducing their screen failure rate.

Alternative System Performance Table Compiled from Field Sites

The following table highlights the observed performance of the product system and the relevant conditions of the demonstration, as recorded by the printers using the products at the demonstration facilities. In addition to the field demonstration performance data, results of the product tests performed at SPTF are also summarized in this table. More descriptive information on the demonstration facilities is included in the section following the table.

Facility Profiles

General Facility Background for Facility 10

Facility 10 prints store displays, primarily on paper, but they also print on plastics, metal, ceramic, glass, and other materials. Their typical run length is 200 - 500 impressions and less than 5% of their orders are repeat orders. Of the approximately 25 employees at this

Table V-111
On-Site Performance Summary For System Delta

	System Component	Performance						Demonstration Conditions			
		Avg Drying Time Before Using Product	Average Quantity Applied	Average Cleaning Time	Average Effort Required	Performance for Each System Component	Overall System Performance	Ink type(s)	Emulsion type	Mesh type; Thread count	Average Screen Size
In-field Demonstrations at Volunteer Printing Facilities											
Facility 10	*Ink remover*	17.4 ± 40.9 hr (n=18)	9.9 ± 4.2 oz. (n=18)	9.2 ± 2.1 mins (n=16)	Moderate	Removed ink well on 67% of screens; Slight residue on 33%.	• This facility used their own haze remover on most screens. • Ink remover performance was considered average.	UV-curable	Direct photo stencil	Twill weave; 305 - 390 threads/ inch	7767 in^2
	Emulsion Remover	17.2 ± 32.7 hr (n=18)	8.6 ± 1.5 oz. (n=18)	4.7 ± 2.2 mins (n=18)	Moderate	Easily removed stencil.					
	Haze Remover	3.0 mins (n=1)	1.0 oz. (n=1)	17.0 mins (n=1)	Moderate	Did not remove haze.					
Facility 11	*Ink Remover*	11.4 ± 22.2 hr (n=30)	7.7 ± 3.5 oz. (n=29)	6.3 ± 3.3 mins (n=29)	Low/ Moderate	Consistently removed ink well.	• All screens were reusable. • Print image quality was excellent. • No haze remover needed.	UV-curable	Direct photo stencil	Monofilament twill weave; 390 threads/ inch	5291 in^2
	Emulsion Remover	4.7 ± 14.4 min (n=31)	8.0 ± 3.5 oz. (n=30)	6.0 ± 3.2 mins (n=31)	Low/ Moderate	Easily removed stencil.					
	Haze Remover	not needed	not needed	not needed	not needed	Not needed.					

Table V-112
Laboratory Performance Summary For System Delta

	System Component	Performance						Demonstration Conditions			
		Avg Drying Time Before Using Product	Average Quantity Applied	Average Cleaning Time	Average Effort Required	Performance for Each System Component	Overall System Performance	Ink type(s)	Emulsion type	Mesh type; Thread count	Average Screen Size
Laboratory Testing at SPTF											
SPTF UV-curable Ink	*Ink Remover*	15 mins	1.0 oz.	3.5 mins	Med	Moderate ink residue remaining. Half of stencil peeled off.		UV-curable	Dual cure direct	Polyester; 390 threads/inch	360 in^2
	Emulsion Remover	24 hours	1.0 oz.	4.8 mins	Med	Removed stencil. Ink residue remaining.					
	Haze Remover	0 mins	1.5 oz.	2.5 mins	Low	Removed residue. Dark ink stain left.					
SPTF Solvent-based Ink	*Ink Remover*	15 mins	1.0 oz.	4.5 mins	Med	Moderate ink residue remaining; some stencil deterioration.		Solvent-based	Dual cure direct	Polyester; 255 threads/inch	360 in^2
	Emulsion Remover	24 hours	1.5 oz.	3.7 mins	Med	Removed stencil completely. Ink residue remaining.					
	Haze Remover	0 mins	2.0 oz.	3.5 mins	Low	Removed residue; moderate ink stain left.					
SPTF Water-based Ink	*Ink Remover*	15 mins	2.5 oz.	7.1 mins	Med	Slight ink residue remaining. Dissolved most of the stencil.		Water-based	Dual cure direct	Polyester; 255 threads/inch	360 in^2
	Emulsion Remover	24 hours	1.0 oz.	3.8 mins	Low	Removed stencil completely. Slight ink residue and some ink stain remaining.					
	Haze Remover	0 mins	1.5 oz.	2.8 mins	Low	Removed residue. Slight ink stain left.					

facility, 1 - 3 are involved in screen reclamation activities. The screens used in the Performance Demonstrations were twill mesh with mesh counts of 305 - 390 threads/inch and a direct photo stencil was applied. The average screen size at this facility is 70 inches x 100 inches and 5 - 10 screens are reclaimed daily.

Screen Reclamation Area in Facility 10

Ink removal is done near the press where plant wide ventilation is provided. Screen reclamation is done in a separate room which is ventilated to the main production area. Within the reclamation room, there is a back-lit spray booth with a vented hood. During the observer's visit, the ambient conditions in the ink removal area were 67°F and 45% relative humidity. In the screen reclamation room, the temperature averaged 63°F and the relative humidity was 60%. Reusable rags used for ink removal are cleaned by a laundry service. Waste water from the wash in emulsion removal and haze removal is filtered prior to disposal.

Current Screen Reclamation Products at Facility 10

Facility 10 uses a proprietary blend ink remover consisting of at least propylene glycol ethers and dimethyl adipate. For emulsion removal, they use a proprietary aqueous mixture which contains periodate salt (<10%). Their haze remover is a proprietary aqueous mixture which contains sodium hydroxide (<15%).

Current Screen Reclamation Practices in Facility 10

Using their standard products, this facility reclaims their screens following the procedure described below:

- Ink Remover: Immediately after the print run, card off excess ink at the press. Saturate a reusable rag in ink remover and wipe remaining ink off the screen. Approximately 2 - 4 rags are used for each screen. Gloves are worn during ink removal.

- Emulsion Remover: Rinse the screen with a pressure washer (1500 psi). Spray emulsion remover onto both sides of the screen and scrub with a scrubber pad. Pressure rinse on both sides. Gloves, eye protection, respiratory protection, and ear protection are available to employees during emulsion removal and haze removal activities.

- Haze Remover: If there are any ink stains or stencil stains on the screen, reapply the ink remover or the emulsion remover where needed. Pressure rinse again. If the second application does not clean the screen sufficiently, then apply the haze remover. Typically, haze remover is only required on 2 - 5% of the screens reclaimed. To apply, dip a bristle brush into the pail of haze remover. Brush the haze remover into both sides of the screen and let sit for one minute. Rinse the screen with a high pressure water spray.

General Facility Background for Facility 11

Facility 11 prints fleet graphics and pressure sensitive decals. Typically, they print about 100 units per run and 50% of their orders are repeat orders. There are approximately 35 employees at this facility, and 1 - 3 people are involved in screen reclamation activities. During the Performance Demonstrations, this facility used UV-cured inks and a direct photo stencil.

Screens with a monofilament twill weave and a mesh count of 390 threads/inch were used. The average screen frame size used in this facility is 68 inches x 88 inches and approximately 5 screens are reclaimed per day.

Screen Reclamation Area in Facility 11

Ink removal and screen reclamation are both done in the same area of the facility which is 50 - 100 ft^2 in size. Natural ventilation and a shipping door next to the back-lit reclamation spray booth provide air flow for the area. During the observer's visit, the average temperature in the area was 59°F (and 42% relative humidity). Ink removal waste is sent to an off-site recycler. Waste water from the washes of the emulsion remover and haze remover is not recycled or filtered at this facility.

Current Screen Reclamation Products at Facility 11

Facility 11 uses a standard ink remover that is a proprietary product, sold by a manufacturer not participating in this project. According to the MSDS, this product contains no carcinogens, no ingredients with TLVs or PELs, and no petroleum derivatives. Information on the emulsion remover used at Facility 11 was not available. Their haze remover is a proprietary aqueous mixture that contains sodium hydroxide (<15%).

Current Screen Reclamation Practices in Facility 11

Screen reclamation at Facility 11 usually follows the procedure detailed below. One exception is when there is a clear coat on the screen. In this case, lacquer thinner is applied to remove the clear coat prior to the ink removal step. Haze remover is rarely used at this facility (on approximately 1 - 3% of the screens reclaimed). It is usually only required when there is excessive adhesive and block out on the screen. During the screen reclamation process at Facility 11, gloves and eye protection are worn. Screens are reclaimed as follows:

- Ink Remover: At the press, card off the excess. Bring the screen to the screen reclamation area and spray on the ink remover. Remove the ink by running a squeegee across the screen. Wipe off both sides of the screen with a reusable rag (2 - 4 rags are used on each screen) and pressure rinse (1000 psi).

- Emulsion Remover: Dip a scrubber pad with a handle into the container of emulsion remover and scrub the product on the stencil side of the screen. Repeat dipping and scrubbing until stencil is covered (4 - 5 dips). Turn the screen over and spray emulsion remover on the other side of the screen. Let the remover sit on the screen for one or two minutes. Pressure rinse.

- Haze Remover: A haze remover is rarely used (on approximately 1 - 3% of the screens reclaimed). When haze remover is used, apply as follows: dip a brush in the product container, rub the haze remover into the screen, and rinse with a high pressure wash. Lacquer thinner is used to remove any stains remaining on the screen.

Cost

Table V-113
Method 2: Summary of Cost Analysis for Alternative System Delta

Cost Element Description		Baseline (Traditional System 4)	Alternative System Delta	
			Facility 11	Facility 10
Facility Characteristics				
Average screen size (in^2)		2,127	5,292	7,767
Average # screens/day		6	5	8
Cost Elements per Screen				
Labor	Time spent applying, scrubbing, and removing reclamation products (min)	24.4	12.3	30.9
	Cost ($)	5.33	2.69	6.76
Materials and Equipment	# of rags used	3	0.0	6.5
	Cost ($)	0.45	0.0	0.97
Reclamation Product Use	Ink Remover Average Volume (oz.)	8.0	7.7	9.9
	Cost ($)	0.22	0.99	1.27
	Emulsion Remover Average Volume (oz.)	3.5	8.0	8.6
	Cost ($)	0.13	0.28	0.30
	Haze Remover Average Volume (oz.)	3.0	not used	1.0
	Cost ($)	0.12		0.13
Hazardous Waste Disposal	Amount (g)	34	0	0
	Cost ($)	0.02	0	0
Totals				
Total Cost ($/screen)		6.27	3.96	9.43
Normalized[a]		6.27	3.28	7.66
Total Cost ($/year)		9,399	4,953	17,675
Normalized[a]		9,399	4,917	11,489

[a]Normalized values adjust product usage, number of screens cleaned, and number of rags laundered at demonstration facilities to reflect the screen size and number of screens cleaned per day under the baseline scenario. Labor costs, however, are not normalized. Normalization allows a comparison between the baseline and facility results.

Note: For additional information regarding product performance see performance demonstration summaries.

Product System Epsilon

Formulation

Ink Remover	Cyclohexanone
	Methoxypropanol acetate
	Diethylene glycol
	Benzyl alcohol
	Diacetone alcohol
	Aromatic solvent naphtha
	Derivatized plant oil
Emulsion Remover	Sodium periodate
	Sulfate salt
	Water
Haze Remover	Alkyl benzene sulfonates
	Ethoxylated nonylphenol
	Phosphate salt
	Sodium hydroxide
	Derivatized plant oil
	Water
	Cyclohexanone
	Methoxypropanol acetate
	Diethylene glycol
	Benzyl alcohol
	Diacetone alcohol
	Aromatic solvent naphtha
	Derivatized plant oil

Occupational Exposure

Table V-114
Occupational Exposure Estimates for Epsilon System

System	Inhalation (mg/day)				Dermal (mg/day)	
	I	II	III	IV	Routine	Immersion
Ink Remover						
Cyclohexanone	39	0.3	0.2	1.4	468	2180
Methoxypropanol acetate	17	0.4	0.2	1.7	234	1090
Diethylene glycol	0	0	0	0	312	1460
Benzyl alcohol	0.1	0	0	0	101	473
Derivatized plant oil	0.1	0	0	0.2	55	255
Aromatic solvent naphtha	1.6	0.1	0	0.2	156	728
Diacetone alcohol	4.6	0.1	0.1	0.4	234	1090
Emulsion Remover (diluted 1:4)						
Sodium periodate	0	0	0	0	23	109
Sulfate salt	0	0	0	0	23	109
Water	0	0	0	0	1510	7060
Haze Remover						
Cyclohexanone	12	0.3	0.2	0	234	109
Methoxypropanol acetate	5.2	0.4	0.2	0	117	546
Diethylene glycol	0	0	0	0	156	728
Benzyl alcohol	0	0	0	0	51	273
Derivatized plant oil	0	0	0	0	27	127
Aromatic solvent naphtha	0.5	0.1	0	0	78	364
Diacetone alcohol	1.4	0.1	0.1	0	62	291
Alkyl benzene sulfonates	0	0	0	0	140	655
Ethoxylated nonylphenol	0	0	0	0	62	291
Phosphate salt	0	0	0	0	117	546
Alkali/Caustic	0	0	0	0	408	1890
Water	0	0	0	0	109	510

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry

Occupational Risk Conclusions and Observations

Ink Remover and Haze Remover

- Hazard quotient calculations indicate marginal concerns for chronic dermal exposures to cyclohexanone and benzyl alcohol during both ink removal and haze removal. Similar calculations for inhalation exposures to cyclohexanone and benzyl alcohol indicate low concern.

- Margin-of-exposure calculations indicate a marginal concern for developmental toxicity risk from inhalation exposures to cyclohexanone during ink removal. Reproductive and developmental toxicity risks from dermal exposures to cyclohexanone could not be quantified.

- Hazard quotient calculations indicate marginal concerns for chronic dermal exposures and low concern for chronic inhalation exposures to methoxypropanol acetate.

- Risks from other ink remover and haze remover components could not be quantified because of limitations in hazard data, although dermal exposures to all components could be relatively high.

Emulsion Removers (All Systems)

- All of the systems that employ an emulsion remover use either a strong oxidizer such as hypochlorite or periodate or a strong base such as sodium hydroxide. The haze removers in Alpha, Epsilon, Gamma, Mu, Omicron, and Theta also contain these compounds. All of these materials present a high concern for skin and eye irritation and tissue damage if workers are exposed in the absence of proper protective clothing. None of the emulsion removers present significant inhalation risks.

Exhibit V-115
Occupational Risk Estimates for System Epsilon

Name	Hazard Quotient[b]			Margin Of Exposure[a]					
		Dermal		Inhalation		Dermal			
						Routine		Immersion	
	Inhalation	Routine	Immersion	NOAEL[c]	LOAEL[d]	NOAEL	LOAEL	NOAEL	LOAEL
Ink Remover									
Cyclohexanone	0.12	1.3	6.2	120	NA	NA	NA	NA	NA
Methoxypropanol acetate	0.45	5.6	26	0	NA	NA	NA	NA	NA
Diethylene glycol	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzyl alcohol	0.004	4.8	23	NA	NA	NA	NA	NA	NA
Derivatized plant oil	NA	NA	NA	NA	NA	NA	NA	NA	NA
Aromatic solvent naphtha	NA	NA	NA	NA	NA	NA	NA	NA	NA
Diacetone alcohol	NA	NA	NA						
Emulsion Remover (diluted to 3%)									
Sodium periodate	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sulfate salt	NA	NA	NA	NA	NA	NA	NA	NA	NA
Water	NA	NA	NA	NA	NA	NA	NA	NA	NA

[a]Margin of Exposure (MOE) values above 100 for a NOAEL and 1000 for a LOAEL indicate low risk.
[b]Hazard Quotient is the ratio of the estimated chronic dose/exposure level to the Reference Dose (RfD) or the Reference Concentration (RfC). Hazard Quotient values less than 1 imply that adverse effects are very unlikely to occur.
[c]NOAEL means No Observed Adverse Effect Level.
[d]LOAEL means Lowest Observed Adverse Effect Level.

Exhibit V-116
Occupational Risk Estimates for System Epsilon

Name	Hazard Quotient[b]			Margin Of Exposure[a]					
		Dermal		Inhalation		Dermal			
						Routine		Immersion	
	Inhalation	Routine	Immersion	NOAEL[c]	LOAEL[d]	NOAEL	LOAEL	NOAEL	LOAEL
Haze Remover									
Cyclohexanone	0.03	0.8	3.6	400	NA	NA	NA	NA	NA
Methoxypropanol acetate	0.14	2.8	13	NA	NA	NA	NA	NA	NA
Diethylene glycol	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzyl alcohol	NA	1.8	8.7	NA	NA	NA	NA	NA	NA
Derivatized plant oil	NA	NA	NA	NA	NA	NA	NA	NA	NA
Aromatic solvent naphtha	NA	NA	NA	NA	NA	NA	NA	NA	NA
Diacetone alcohol	NA	NA	NA	NA	NA	NA	NA	NA	NA
Alkyl benzene sulfonates	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ethoxylated nonylphenol	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phosphate salt	NA	NA	NA	NA	NA	NA	NA	NA	NA
Alkali/Caustic	NA	NA	NA	NA	NA	NA	NA	NA	NA
Water	NA	NA	NA	NA	NA	NA	NA	NA	NA

[a]Margin of Exposure (MOE) values above 100 for a NOAEL and 1000 for a LOAEL indicate low risk.
[b]Hazard Quotient is the ratio of the estimated chronic dose/exposure level to the Reference Dose (RfD) or the Reference Concentration (RfC). Hazard Quotient values less than 1 imply that adverse effects are very unlikely to occur.
[c]NOAEL means No Observed Adverse Effect Level.
[d]LOAEL means Lowest Observed Adverse Effect Level.

Environmental Releases

Table V-117
Environmental Release Estimates in Screen Cleaning Operations
Method 2, Alternative System Epsilon

System	Release Under Each Scenario (g/day)						
	I			II	III	IV	
	air	land	water	air	air	air	water
Ink Remover							
Cyclohexanone	82	126	00	0.7	0.4	2.9	402
Methoxypropanol acetate	36	68	0	0.8	0.5	3.6	199
Diethylene glycol	0	138	0	0	0	0	270
Benzyl alcohol	0.2	45	0	0	0	0	88
Derivatized plant oil	0.2	24	0	0.1	0	0.3	47
Aromatic solvent naphtha	3.2	66	0	0.1	0.1	0.5	135
Diacetone alcohol	9.6	94	0	0.2	0.1	0.8	202
Emulsion Remover (diluted to 3%)							
Sodium periodate	0	0	9	0	0	0	0
Sodium salt	0	0	9	0	0	0	0
Water	0	0	602	0	0	0	0
Haze Remover							
Cyclohexanone	25	0	55	0.7	0.7	0.4	0
Methoxypropanol acetate	11	0	29	0.8	0.8	0.5	0
Diethylene glycol	0	0	53	0	0	0	0
Benzyl alcohol	0.1	0	17	0	0	0	0
Derivatized plant oil	0.1	0	9.3	0.1	0.1	0	0
Aromatic solvent naphtha	1	0	26	0.1	0.1	0.1	0
Diacetone alcohol	2.9	0	37	0.2	0.2	0.1	0
Alkyl benzene sulfonates	0	0	48	0	0	0	0
Ethoxylated nonylphenol	0	0	21	0	0	0	0
Alkali/Caustic	0	0	138	0	0	0	0
Water	0	0	37	0	0	0	0
Phosphate salt	0	0	21	0	0	0	0

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry.

Environmental Releases from Screen Reclamation Processes
Screen Reclamation Method 2, Alternative System Epsilon

From Ink Removal Operations:

Cyclohexanone
- 86 g/day to air
- 402 g/day to water from rags at commercial laundry
- 126 g/day to landfill

Methoxypropanol acetate
- 40.9 g/day to air
- 199 g/day to water at commercial laundry
- 68 g/day to landfill

Diethylene glycol
- 270 g/day to water at commercial laundry
- 138 g/day to landfill

Benzyl alcohol
- 0.2 g/day to air
- 88 g/day to water at commercial laundry
- 45 g/day to landfill

Derivatized plant oil
- 0.6 g/day to air
- 47 g/day to water from rags at commercial laundry
- 24 g/day to landfill

Aromatic solvent naphtha
- 4 g/day to air
- 135 g/day to water from rags at commercial laundry
- 66 g/day to landfill

Diacetone alcohol
- 10.7 g/day to air
- 202 g/day to water from rags at commercial laundry
- 94 g/day to landfill

From Emulsion Remover:

Sodium periodate
- 9 g/day to water

Sulfate salt
- 9 g/day to water

From Haze Remover:

Cyclohexanone
- 26.8 g/day to air
- 55 g/day to water

Environmental Releases from Screen Reclamation Processes
Screen Reclamation Method 2, Alternative System Epsilon (cont.)

Methoxypropanol acetate
13.1 g/day to air
29 g/day to water

Diethylene glycol
53 g/day to water

Benzyl alcohol
0.1 g/day to air
17 g/day to water

Derivatized plant oil
0.3 g/day to air
9.3 g/day to water

Aromatic solvent naphtha
1.3 g/day to air
26 g/day to water

Diacetone alcohol
3.4 g/day to air
37 g/day to water

Alkyl benzene sulfonates
48 g/day to water

Ethoxylated nonylphenol
21 g/day to water

Phosphate salt
21 g/day to water

Sodium hydroxide
138 g/day to water

Table V-118
Summary of Estimated Daily Environmental Releases from a Hypothetical Facility Using Screen Reclamation Method 2, Alternative System Epsilon

Substance:	To Air:	To Water:	To Landfill:
Cyclohexanone	113 g/day	55 g/day 402 g/day at laundry	126 g/day
Methoxypropanol acetate	54 g/day	29 g/day 199 g/day at laundry	68 g/day
Diethylene glycol		53 g/day 270 g/day at laundry	138 g/day
Benzyl alcohol	0.3 g/day	17 g/day 88 g/day at laundry	45 g/day
Derivatized plant oil	0.9 g/day	9.3 g/day 47 g/day at laundry	24 g/day
Aromatic solvent naphtha	5.3 g/day	26 g/day 135 g/day at laundry	66 g/day
Diacetone alcohol	14.1 g/day	37 g/day 202 g/day at laundry	94 g/day
Alkyl benzene sulfonates		48 g/day	
Ethoxylated nonylphenol		21 g/day	
Phosphate salt		21 g/day	
Alkali/Caustic		138 g/day	
Sodium periodate		9 g/day	
Sulfate salt		9 g/day	

Releases to Water from a Single Facility

Table V-119
Estimated Releases to Water from Traditional Formulations from Screen Reclamation at a Single Facility Using Screen Reclamation Method 2, Alternative System Epsilon

Substance	Amount Released to Water from Facility	Waste water Treatment Removal Efficiency	Amount to Water After Waste water Treatment	Daily Stream Concentration, ug/L[a] for 1000 MLD Receiving Water
Cyclohexanone	55 g/day 402 g/day at laundry	83 %	9.4 g/day 68.3 g/day	9×10^{-3} 7×10^{-2}
Methoxypropanol acetate	29 g/day 199 g/day at laundry	97 %	9×10^{-1} g/day 6 g/day	9×10^{-4} 6×10^{-3}
Diethylene glycol	53 g/day 270 g/day at laundry	84 %	8.5 g/day 43.2 g/day	9×10^{-3} 4×10^{-2}
Benzyl alcohol	17 g/day 88 g/day at laundry	97 %	5×10^{-1} g/day 3 g/day	5×10^{-4} 3×10^{-3}
Derivatized plant oil	9.3 g/day 47 g/day at laundry	100 %	0 g/day	0
Aromatic solvent naphtha	26 g/day 135 g/day at laundry	92-96 %	2 g/day 10.8 g/day	2×10^{-3} 1×10^{-2}
Diacetone alcohol	37 g/day 202 g/day at laundry	83 %	6.3 g/day 34 g/day	6×10^{-3} 3×10^{-2}
Alkyl benzene sulfonates	48 g/day	97 %	1.4 g/day	1×10^{-3}
Ethoxylated nonylphenol	21 g/day	100 %	0 g/day	0
Phosphate salt	21 g/day	100 %	0 g/day	0
Sodium hydroxide	138 g/day	100 %	0 g/day	0
Sodium periodate	9 g/day	100 %	0 g/day	0
Sulfate salt	9 g/day	100 %	0 g/day	0

[a]ug/L is Micrograms per liter, which is parts per billion for a substance in water. MLD is Million liters per day.

Releases to Air from Individual Screen Printing Facilities

Table V-120
Air Release, Concentration and Potential Dose Estimates from a Single Model Facility
Using Screen Reclamation Method 2, Alternative System Epsilon

Substance	Amount of Releases per day	Highest Average Concentration 100 M away	Annual Potential Dose, mg/year[a]
Cyclohexanone	113 g/day	2.3×10^{-1} ug/m^3	2
Methoxypropanol acetate	54 g/day	1.1×10^{-1} ug/m^3	8×10^{-1}
Derivatized plant oil	0.9 g/day	1.8×10^{-3} ug/m^3	1×10^{-2}
Aromatic solvent naphtha	5.3 g/day	1.1×10^{-2} ug/m^3	8×10^{-2}
Benzyl alcohol	0.3 g/day	6×10^{-4} ug/ m^3	4×10^{-3}
Diacetone alcohol	14.1 g/day	3×10^{-2} ug/m^3	2×10^{-1}

[a]This estimates doses for people living 100 Meters from the hypothetical facility. The actual number of people who would fall into this range can be determined from census data, if the facility location is known. The model used to calculate concentrations is more completely explained in the Overview by Media-Air Section in Chapter III. To calculate the annual potential dose, the concentration is multiplied by the amount a person will breathe (20 m^3/day) and the number of days per year (365), and the units are converted to mg/year by dividing by 1000.

General Population Risk Conclusions and Observations

- Health risks to the general population from both air and water exposures are very low for Method 2, Product System Epsilon.

Although air releases were evaluated for only a single facility, it is very unlikely that an analysis of cumulative air releases would lead to different risk conclusions. Examples of general population exposure and risk estimates are shown for Method 2, Traditional System 1 in Methods 1 and 2 and Alternative System Chi in Method 2; please reference these sections as illustrative examples. Hazard Quotient values below one indicate very low risk. Margin-of-Exposure (MOE) values above 100 for a NOAEL or above 1000 for a LOAEL indicate very low risk.

Ecological Risks From Water Releases Of Screen Reclamation Chemicals

- None of the single facility releases of Method 2, Product System Epsilon reach an ecotoxicity concern concentration.

Performance

General Summary of Product System Epsilon, Performance, and Related Variables

This product system consisted of an ink remover, emulsion remover and haze remover. It's performance was demonstrated at Facility 20 and Facility 24. Facility 20 employs approximately 10 people and prints mainly banners and displays. Facility 24 employs 15 - 20 people in their production area with 4 employees involved in the screen printing operations of their business. They print pressure sensitive labels and Lexan face plates. Over a thirty-day period, Facility 20 reclaimed 48 screens and Facility 24 reclaimed 16 screens using Product System Epsilon. Both facilities used solvent-based inks, and Facility 24 also used UV-curable inks. Facility 20 used a dual-cured emulsion and Facility 24 used a direct photo stencil.

There were some differences between the two facilities in their evaluations of the performance of Product System Epsilon. Facility 20 found the ink remover was effective, but it took longer to breakdown the ink than their standard product. Facility 24 had very good results with the ink remover. They felt it worked as well as the products they had used previously and they were using less product per screen. The ink remover worked well on both UV and solvent-based inks, but the UV ink was easier to clean than the solvent-based ink.

The alternative emulsion remover performance was very good at both facilities. The two facilities reported that the performance was even better than their standard products; it dissolved the stencil quickly and easily.

Both facilities thought that the haze remover performance was acceptable, and in most cases, it worked as well as their other products.

Alternative System Epsilon Profile

The manufacturer recommends applying Product System Epsilon as follows:

- Ink Remover After carding off as much excess ink as possible, spray both sides of the screen with the ink remover. Also spray a rag and rub both sides of the screen until all ink residue is completely dissolved or emulsified and the emulsion becomes clearly visible. Rinse well with water.

- Emulsion Remover Dilute the powdered emulsion remover in water as follows: 1% for photoemulsions, 2% for fast exposing solvent resistant emulsion, 3% for dual-cured and water resistant photo emulsions. Stir thoroughly until the product is dissolved. Pour the diluted mixture into a spray bottle. Spray the solution on both sides of the screen. Rub the screen gently with a brush for approximately two minutes. Rinse thoroughly with a high pressure water spray. A 1000 psi pressure wash was used at SPTF. If any ink residue remains, apply additional ink remover to the screen, brush it in for a few minutes until emulsified, and pressure rinse.

- Haze Remover Create a mixture of haze remover and ink remover in a ratio of 1:4 to 1:1. Scoop out the mixture and apply it to a brush. Brush the paste into both sides of the screen. Wait for a minimum of 10 minutes up to a maximum of 30 minutes. Rinse the mixture off with running water and then spray out the dissolved and softened residue with a high pressure washer.

Alternative System Performance at SPTF

Product System Epsilon was used at SPTF on three screens (one with a solvent-based ink, one with a UV-curable ink, and the third with water-based ink). The ink remover dissolved the solvent-based ink well and was easy to use. A light grey haze was left on the screen. On the screen with UV ink, the ink dissolved quickly, wiped off easily, rinsed clean of residue, but left a moderate ink stain. When used on the screen with water-based ink, more time and effort were needed to remove the ink which seemed to dry in the screen. With the extra effort, the ink was removed except for a light ink stain. For each of the three screens, one rag was used to remove the ink.

On all three screens, the emulsion remover dissolved the stencil with some scrubbing. The remainder of the stencil came off easily with the pressure wash. There was no emulsion stain or residue on any of the screens. On the screen with the solvent-based ink, a moderate ink stain remained after using the emulsion remover. The UV ink screen and the water-based ink screen had light stains. On all the screens, the haze remover lightened the ink stain, but did not remove it completely; a light ink stain was still visible.

Manufacturer's instructions were followed in applying the products to the screen. The technician noted that the ink remover had an unpleasant odor, but that it was not very strong.

Alternative System Performance Details

Performance Details from Facility 20

Users of the reclaiming products were asked to evaluate the performance of the components of System Epsilon relative to the facility's regular system. The screen reclaimer thought that the products were generally better than their previously used ones. The operations manager, however, felt that the ink remover did not perform quite as well in cutting some inks as their previously used products. No evaluation sheets were received from Facility 20, although the facility reported that they sent them. Unfortunately, they did not make copies of the sheets before they were mailed. Therefore, all performance information from Facility 20 was received through the observer's on-site documentation and through weekly telephone conversations with the facility. The observer interviewed both the reclamation employee and the operations manager, who was also one of the printers who used the ink remover.

The ink remover worked acceptably in the facility, although some of the printers who used it complained that it acted slowly. Performance was not as good on catalyzed inks as on other solvent-based inks. The catalyzed inks also require more effort to remove with the facility's regular ink remover, but the alternative ink remover did not perform as well as the regular product in this case. The alternative product did eventually remove all the ink from the screens. The operations manager, who also used the product, commented that it was more of an respiratory irritant than their previously used product; he said that the alternative ink remover smelled bad and made him dizzy.

The emulsion remover worked well at this facility. One screen, with an 83 mesh screen that had been used with an aggressive ink system, required at least two applications of emulsion remover to clean. Two applications of emulsion remover are also required when using the facility's standard emulsion remover with this type of screen. The reclaimer felt that either the coarse mesh or the ink system could have made the screen more difficult to clean.

Haze remover performance was acceptable. Again, when reclaiming screens with a mesh count of 83 threads per inch, the haze remover also had to be applied 2 or 3 times.

Overall, the use of Product System Epsilon had no deleterious effects on the screen mesh or on the subsequent print quality image and the printer did not notice any change in screen failure rate over the time period that the alternative system was in use.

Performance Details from Facility 24

This facility felt the ink remover and the emulsion remover worked better than their standard system, and the haze remover performed as well as their own product. Screen printing is a relatively small part of the operations at this facility, and although they used Product System Epsilon on all the screens they reclaimed, the total number of screens over four weeks was 14.

The ink remover consistently removed the both the solvent-based and the UV-curable inks. Although the product performance was good for both ink types, this printer found the UV inks easier to clean than the solvent-based inks. In addition, the facility found the quantity of alternative ink remover used per screen was significantly less than the quantity used of standard product.

The printer felt the emulsion remover was as effective as their standard product, and it dissolved the stencil quickly.

Product System Epsilon haze remover performance was evaluated as the same as the facility's standard haze remover. Although the data from this facility indicates that there were several cases where the screen could not be reused for reverse printing or for use with transparent inks, the printer felt that these restrictions were not entirely due to the alternative system. Some of the remaining ink stains may have been on the screen prior to the start of the demonstrations.

During the four weeks the products were used in this facility, no change in the screen failure, mesh deterioration, or print quality were noted. The observer felt the facility evaluated the alternative system's performance objectively and conscientiously. At the conclusion of the demonstrations, the printer mentioned that he was interested in continuing to use the alternative ink remover and emulsion remover.

Alternative System Performance Table Compiled from Field Sites

The table below highlights the observed performance of the product system and the relevant conditions of the demonstration, as recorded by the printers using the products at the demonstration facilities. In addition to the field demonstration performance data, results of the product tests performed at SPTF are also summarized in this table. More descriptive information on the demonstration facilities is included in the section following the table.

Facility Profiles

General Facility Background for Facility 20

Facility 20 prints banners and point-of-purchase displays on paper, plastic, metals, ceramics, and glass. Their typical run is 20 parts and about 20% of their orders are repeat orders. Of the approximately 10 employees at this facility, 1 - 3 are involved in screen

Table V-121
On-Site Performance Summary For System Epsilon

	System Component	Performance						Demonstration Conditions			
		Avg Drying Time Before Using Product	Average Quantity Applied	Average Cleaning Time	Average Effort Required	Performance for Each System Component	Overall System Performance	Ink type(s)	Emulsion type	Mesh type; Thread count	Average Screen Size
In-field Demonstrations at Volunteer Printing Facilities											
Facility 20	*Ink remover*	no data	3.0 oz. (n=1)	no data	Moderate	Removed ink well, but took some extra time.	• Data forms were not received from this facility. • All information is based on weekly phone calls.	Solvent-based vinyl, enamels	Dual cure	Polyester; 83 - 280 threads/inch	2538 in^2
	Emulsion Remover	no data	3.3 ± 0.6 oz. (n=3)	no data	Moderate	Easily removed stencil.					
	Haze Remover	no data	4.0 ± 1.7 oz. (n=3)	no data	Moderate	Lightened ink stain.					
Facility 24	*Ink Remover*	10.3 ± 26.1 hrs (n=14)	4.2 ± 1.7 oz. (n=14)	3.7 ± 1.5 mins (n=13)	Moderate	Removed ink well, especially UV ink.	• All screens could be reused after reclamation. • Some screens could not be used for reverse printing. • Light ink stain remained.	Solvent-based and UV-curable	Direct photo stencil	Monofilament Polyester, no treatment; 355 threads/inch	1296 in^2
	Emulsion Remover	13.8 ± 12.2 hrs (n=14)	4.2 ± 1.9 oz. (n=13)	3.7 ± 1.1 mins (n=14)	Low	Easily removed stencil.					
	Haze Remover	2.9 ± 2.1 mins (n=14)	1.5 ± 0.5 oz. (n=14)	10.9 ± 4.7 mins (n=14)	Low	Usually removed haze.					

Table V-122
Laboratory Performance Summary For System Epsilon

	System Component	Performance						Demonstration Conditions			
		Avg Drying Time Before Using Product	Average Quantity Applied	Average Cleaning Time	Average Effort Required	Performance for Each System Component	Overall System Performance	Ink type(s)	Emulsion type	Mesh type; Thread count	Average Screen Size
Laboratory Testing at SPTF											
SPTF Solvent-based Ink	*Ink Remover*	15 mins	1.5 oz.	3.9 mins	Low	Dissolved ink well; gray haze left on screen.		Solvent-based	Dual cure direct	Polyester; 260 threads/inch	360 in^2
	Emulsion Remover	24 hours	1.0 oz.	3.4 mins	Moderate	Dissolved stencil; medium ink stain remaining.					
	Haze Remover	0 mins	1.0 oz.	31.8 mins	Low	Lightened ink stain.					
SPTF UV-curable Ink	*Ink Remover*	15 mins	1.5 oz.	3.3 mins	Low	Dissolved ink well; has unpleasant odor.		UV-curable	Dual cure direct	Polyester; 390 threads/inch	360 in^2
	Emulsion Remover	24 hours	1.5 oz.	3.8 mins	Moderate	Dissolved stencil; light ink stain remaining.					
	Haze Remover	0 mins	1.0 oz.	2.2 mins	Low	Lightened ink stain.					
SPTF Water-based Ink	*Ink Remover*	15 mins	1.5 oz.	5.6 mins	Moderate	Dissolved ink with scrubbing.		Water-based	Dual cure direct	Polyester; 260 threads/inch	360 in^2
	Emulsion Remover	24 hours	1.0 oz.	3.2 mins	Moderate	Dissolved stencil; light ink stain remaining.					
	Haze Remover	0 mins	1.0 oz.	32.8 mins	Low	Lightened ink stain.					

reclamation activities. The facility uses a variety of solvent-based inks including vinyl, enamel, and a multipurpose ink. They use a dual cure emulsion. Screens used in the Performance Demonstrations were polyester (untreated) with a mesh count of 83 -280 threads/inch. The average screen size at this facility is 4 feet x 5 feet and approximately 5 - 10 screens are reclaimed daily.

Screen Reclamation Area in Facility 20

The ink removal and screen reclamation activities are done in the press room in a back-lit spray booth. A plant-wide system provides the ventilation for the screen reclamation area. The average temperature during the observer's visit was 68°F (and 36% relative humidity). Ink waste is disposed of as hazardous waste. Waste water from the high-pressure wash of the emulsion remover and haze remover is not recycled or filtered at this facility.

Current Screen Reclamation Products at Facility 20

The standard ink remover product at Facility 20 is an acetone blend. For emulsion removal, they use a proprietary aqueous mixture which includes periodate salt (<10%). Their standard haze remover is a proprietary aqueous mixture with sodium hydroxide (<15%).

Current Screen Reclamation Practices in Facility 20

This facility uses a custom blended ink remover. The application procedure listed below is used for most screens. One exception is the 83 mesh, where two applications of the emulsion remover are required. Occasionally, a dried ink requires an initial rinse with cyclohexanone. The screen reclamation process is described below:

- Ink Remover: Card off excess ink from the screen. Apply ink remover to a reusable rag from a safety can. Gloves and eye protection are usually worn during this step. Brush the product into the screen. Wipe the screen with a reusable rag. Continue wiping with clean rags until ink no longer comes off on the rag. Typically, 2 - 4 rags are used on each screen.

- Emulsion Remover: After ink removal, rinse the screen with the hose. Apply the emulsion remover with a spray bottle. Scrub in the product with a pad brush. Rinse the screen with a pressure wash (100 psi).

- Haze Remover: To apply haze remover, dip a bristle brush into the pail of product. Brush the haze remover into both sides of the screen and let sit for one minute. Rinse the screen with a high pressure water spray. If the stain is dark, reapply the haze remover and let sit for 1 - 2 minutes and rinse again with the high pressure spray.

General Facility Background for Facility 24

The majority of the products printed by Facility 24 are pressure sensitive mylar labels and polycarbonate Lexan face plates. Run lengths are typically 500 - 1000 impressions, and approximately 50% of their business is for repeat orders. There are 15 - 20 employees involved in production operations at this facility and 2 - 3 are involved in screen reclamation operations. The facility uses both solvent-based inks and UV inks; sometimes on the same screen. They use a direct photo stencil and a monofilament (untreated) polyester mesh. All screens used in

the Performance Demonstrations had a mesh count of 355 threads/inch. The average screen size at this facility is 36" x 36" and 3 - 5 screens are reclaimed each week.

Screen Reclamation Area in Facility 24

Ink removal is done at press side and screen reclamation takes place nearby in a spray booth. The high ceilings and facility-wide ventilation cover both work areas. During the observer's visit, the average temperature in the area was 68°F (and 40% relative humidity). Rags used for ink removal are cleaned under a contract with a laundry service. Waste water from screen reclamation is not recycled or filtered.

Current Screen Reclamation Products at Facility 24

Facility 24 uses a proprietary solvent blend ink remover consisting primarily of cyclohexanone, diacetone alcohol and dipropylene glycol methyl ether. Their emulsion remover is a proprietary aqueous mixture with at least sodium periodate. Their standard haze remover is an aqueous blend consisting of sodium hydroxide (5%) and tetrahydrofurfuryl alcohol (<15%).

Current Screen Reclamation Practices in Facility 24

At Facility 24, all screens are reclaimed following the application procedure below:

- Ink Remover: At the press, scrape the excess ink off the screen. Wearing gloves, eye protection, and an apron, pour the ink remover onto the screen from a one-gallon can. Scrub with an abrasive brush. Wipe the screen with reusable rags until ink no longer comes off on the rag. Rinse the screen with a pressure wash (500 psi).

- Emulsion Remover: Spray emulsion remover onto both sides of the screen. Work the product into the screen using a scrubber pad. Rinse both sides of the screen with a high pressure wash. After washing off the emulsion, spray the screen with an ink degradent. Wait for one minute. Scrub the screen with a brush and pressure rinse both sides.

- Haze Remover: Wearing gloves and eye protection, dip a brush into the bucket of haze remover. Brush the product into the screen on the effected area on both sides. Wait for 15 minutes. Rinse both sides of the screen with a high-pressure wash.

Cost

Table V-123
Method 2: Summary of Cost Analysis for Alternative System Epsilon

Cost Element Description		Baseline (Traditional System 4)	Alternative System Epsilon	
			Facility 20	Facility 24
Facility Characteristics				
Average screen size (in^2)		2,127	2,538	1,296
Average # screens/day		6	8	1
Cost Elements per Screen				
Labor	Time spent applying, scrubbing, and removing reclamation products (min)	24.4	9.7	18.3
	Cost ($)	5.33	2.12	4.00
Materials and Equipment	# of rags used	3	7.0	3.8
	Cost ($)	0.45	1.05	0.57
Reclamation Product Use	Ink Remover Average Volume (oz.)	8.0	3.0	4.2
	Cost ($)	0.22	0.18	0.26
	Emulsion Remover Average Volume (oz.)	3.5	3.3	4.2
	Cost ($)	0.13	0.09	0.11
	Haze Remover Average Volume (oz.)	3.0	4.0	1.5
	Cost ($)	0.12	0.27	0.10
Hazardous Waste Disposal	Amount (g)	34	112	57
	Cost ($)	0.02	0.08	0.04
Totals				
Total Cost ($/screen)		6.27	3.79	5.08
	Normalized[a]	6.27	3.08	5.29
Total Cost ($/year)		9,399	7,097	1,269
	Normalized[a]	9,399	4,624	7,930

[a]Normalized values adjust product usage, number of screens cleaned, and number of rags laundered at demonstration facilities to reflect the screen size and number of screens cleaned per day under the baseline scenario. Labor costs, however, are not normalized. Normalization allows a comparison between the baseline and facility results.

Note: For additional information regarding product performance see performance demonstration summaries.

Product System Gamma

Formulation

Ink Remover	Propylene glycol series ethers
	Diethylene glycol series ethers
	Dibasic esters
	Fatty alcohol ethers
	Derivatized plant oil
Emulsion Remover	Sodium periodate
	Sulfate salt
	Phosphate salt
	Water
Haze Remover	Sodium hypochlorite
	Alkali/Caustic
	Sodium alkyl sulfonate
	Water

Occupational Exposure

Table V-124
Occupational Exposure Estimates for Alternative System Gamma

System	Inhalation (mg/day)				Dermal (mg/day)	
	I	II	III	IV	Routine	Immersion
Ink Remover						
Diethylene glycol butyl ether acetate	0	0	0	0	62	291
Tripropylene glycol methyl ether	0	0	0	0	780	3640
Derivatized plant oil	0.2	0	0	0.2	62	291
Fatty alcohol ethers	0.4	0	0	0.1	187	873
Dibasic esters	1.3	0	0	0.2	468	2184
Emulsion Remover						
Sodium periodate	0	0	0	0	39	182
Sulfate salt	0	0	0	0	16	73
Phosphate salt	0	0	0	0	117	546
Water	0	0	0	0	1270	5930
Haze Remover						
Sodium hypochlorite	0	0	0	0	585	2730
Alkali/Caustic	0	0	0	0	39	182
Water	0	0	0	0	827	3860
Sodium alkyl sulfate	0	0	0	0	109	510

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry.

Exhibit V-125
Occupational Risk Estimates for System Gamma

Name	Hazard Quotient[b]			Margin Of Exposure[a]					
		Dermal		Inhalation		Dermal			
						Routine		Immersion	
	Inhalation	Routine	Immersion	NOAEL[c]	LOAEL[d]	NOAEL	LOAEL	NOAEL	LOAEL
Ink Remover									
Diethylene glycol butyl ether acetate	NA	NA	NA	NA	NA	2258	57	481	12
Tripropylene glycol methyl ether	NA	NA	NA	NA	NA	NA	NA	NA	NA
Derivatized plant oil	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fatty alcohol ethers	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dibasic esters	NA	NA	NA	NA	NA	NA	NA	NA	NA
Emulsion Remover									
Sodium periodate	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sulfate salt	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phosphate salt	NA	NA	NA	NA	NA	NA	NA	NA	NA
Water	NA	NA	NA	NA	NA	NA	NA	NA	NA

[a]Margin of Exposure (MOE) values above 100 for a NOAEL and 1000 for a LOAEL indicate low risk.
[b]Hazard Quotient is the ratio of the estimated chronic dose/exposure level to the Reference Dose (RfD) or the Reference Concentration (RfC). Hazard Quotient values less than 1 imply that adverse effects are very unlikely to occur.
[c]NOAEL means No Observed Adverse Effect Level.
[d]LOAEL means Lowest Observed Adverse Effect Level.

Exhibit V-126
Occupational Risk Estimates for Alternative System Gamma

Name	Hazard Quotient[b]			Margin Of Exposure[a]					
		Dermal		Inhalation		Dermal			
						Routine		Immersion	
	Inhalation	Routine	Immersion	NOAEL[c]	LOAEL[d]	NOAEL	LOAEL	NOAEL	LOAEL
Haze Remover									
Sodium hypochlorite	NA	NA	NA	NA	NA	NA	NA	NA	NA
Alkali/Caustic	NA	NA	NA	NA	NA	NA	NA	NA	NA
Water	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium alkyl sulfate	NA	NA	NA	NA	NA	192	NA	41	NA

[a]Margin of Exposure (MOE) values above 100 for a NOAEL and 1000 for a LOAEL indicate low risk.
[b]Hazard Quotient is the ratio of the estimated chronic dose/exposure level to the Reference Dose (RfD) or the Reference Concentration (RfC). Hazard Quotient values less than 1 imply that adverse effects are very unlikely to occur.
[c]NOAEL means No Observed Adverse Effect Level.
[d]LOAEL means Lowest Observed Adverse Effect Level.

Occupational Risk Conclusions and Observations

Ink Remover and Haze Remover

- Clear concerns exist for chronic dermal exposures to diethylene glycol butyl ether acetate used in ink removal based on the calculated margin-of-exposure.

- Developmental toxicity risks from dermal exposures to diethylene glycol butyl ether acetate are very low based on the calculated margin-of-exposure.

- Risks from other ink remover and haze remover components could not be quantified because of limitations in hazard data, although dermal exposures to all components could be relatively high.

- Developmental and chronic toxicity risks from dermal exposures to sodium alkyl sulfate in haze remover are very low based on the calculated margin of exposure.

- Inhalation exposures to all components are very low.

Emulsion Removers (All Systems)

- All of the systems that employ an emulsion remover use either a strong oxidizer such as hypochlorite or periodate or a strong base such as sodium hydroxide. The haze removers in Alpha, Epsilon, Gamma, Mu, Omicron, and Theta also contain these compounds. All of these materials present a high concern for skin and eye irritation and tissue damage if workers are exposed in the absence of proper protective clothing. None of the emulsion removers present significant inhalation risks.

Environmental Releases

Table V-127
Environmental Release Estimate for Screen Cleaning Operations
Method 2, Gamma System

System	Release Under Each Scenario (g/day)						
	I			II	III	IV	
	air	water	land	air	air	air	water
Ink Remover							
Diethylene glycol butyl ether acetate	0	0	28	0	0	0	54
Tripropylene glycol methyl ether	0.1	0	355	0	0	0	675
Derivatized plant oil	0.3	0	28	0.1	0	0.3	54
Fatty alcohol ethers	0.8	0	84	0	0	0.1	162
Dibasic esters	3.0	0	210	0	0	0.3	405
Emulsion Remover							
Sodium periodate	0	16	0	0	0	0	0
Sulfate salt	0	6	0	0	0	0	0
Phosphate salt	0	47	0	0	0	0	0
Water	0	506	0	0	0	0	0
Haze Remover							
Sodium hypochlorite	0	200	0	0	0	0	0
Alkali/Caustic	0	13	0	0	0	0	0
Water	0	282	0	0	0	0	0
Sodium alkyl sulfate	0	37	0	0	0	0	0

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry

Table V-128
Summary of Estimated Daily Environmental Releases from a Hypothetical Facility Using Screen Reclamation Method 2, Alternative System Gamma

Substance:	To Air:	To Water:	To Landfill:
Diethylene glycol butyl ether acetate		54 g/day from laundry	28 g/day
Tripropylene glycol methyl ether	0.1 g/day	675 g/day from laundry	355 g/day
Derivatized plant oil	0.7 g/day	54 g/day at laundry	28 g/day
Fatty alcohol ethers	0.9 g/day	162 g/day at laundry	86 g/day
Dibasic esters	3.0 g/day	405 g/day at laundry	210 g/day
Sodium periodate		16 g/day	
Sulfate salt		6 g/day	
Phosphate salt		47 g/day	
Other		47 g/day	
Sodium hypochlorite		200 g/day	
Alkali/caustic		13 g/day	
Sodium alkyl sulfate		37 g/day	

Releases to Water from a Single Facility

Table V-129
Estimated Releases to Water from Traditional Formulations from Screen Reclamation at a Single Facility Using Screen Reclamation Method 2, Alternative System Gamma

Substance	Amount Released to Water from Facility	Waste water Treatment Removal Efficiency	Amount to Water After Waste water Treatment	Daily Stream Concentration, ug/L[a] for 1000 MLD Receiving Water
Diethylene glycol butyl ether acetate	54 g/day at laundry	83 %	9.2 g/day	9×10^{-3}
Tripropylene glycol methyl ether	675 g/day at laundry	83 %	115 g/day	1×10^{-1}
Derivatized plant oil	54 g/day at laundry	100 %	0	0
Fatty alcohol ethers	162 g/day at laundry	100 %	0	0
Dibasic esters	405 g/day at laundry	84-97 %	28.3 g/day	3×10^{-2}
Sodium Periodate	16 g/day	100 %	0	0
Sulfate salt	6 g/day	100 %	0	0
Phosphate salt	47 g/day	100 %	0	0
Other	47 g/day	100 %	0	0
Sodium hypochlorite	200 g/day	100 %	0	0
Alkali/caustic	13 g/day	100 %	0	0
Sodium alkyl sulfate	37 g/day	100 %	0	0

[a]ug/L is Micrograms per liter, which is parts per billion for a substance in water. MLD is Million liters per day.

Releases to Air from Individual Screen Printing Facilities

Table V-130
Air Release, Concentration and Potential Dose Estimates from a Single Model Facility Using Screen Reclamation Method 2, Alternative System Gamma

Substance	Amount of Releases per day	Highest Average Concentration 100 M away	Annual Potential Dose, mg/year[a]
Tripropylene glycol methyl ether	0.1 g/day	2×10^{-4} ug/m^3	1×10^{-3}
Derivatized plant oil	0.7 g/day	1.4×10^{-3} ug/m^3	1×10^{-2}
Fatty alcohol ethers	0.9 g/day	2×10^{-3} ug/m^3	1×10^{-2}
Dibasic esters	3.0 g/day	5×10^{-3} ug/m^3	5×10^{-2}

[a]This estimates doses for people living 100 Meters from the hypothetical facility. The actual number of people who would fall into this range can be determined from census data, if the facility location is known. The model used to calculate concentrations is more completely explained in the Overview by Media-Air Section in Chapter III. To calculate the annual potential dose, the concentration is multiplied by the amount a person will breathe (20 m^3/day) and the number of days per year (365), and the units are converted to mg/year by dividing by 1000.

General Population Risk Conclusions and Observations

- Health risks to the general population from both air and water exposures are very low for Method 2, Product System Gamma.

Although air releases were evaluated for only a single facility, it is very unlikely that an analysis of cumulative air releases would lead to different risk conclusions. Examples of general population exposure and risk estimates are shown for Method 2, Traditional System 1 in Methods 1 and 2 and Alternative System Chi in Method 2; please reference these sections as illustrative examples. Hazard Quotient values below one indicate very low risk. Margin-of-Exposure (MOE) values above 100 for a NOAEL or above 1000 for a LOAEL indicate very low risk.

Ecological Risks From Water Releases Of Screen Reclamation Chemicals

- None of the single facility releases of Method 2, Product System Gamma reach an ecotoxicity concern concentration.

Performance

General Summary of Product System Gamma Performance, and Related Variables

Product System Gamma, demonstrated at Facilities 16 and 25, consisted of an ink remover, an emulsion remover, and a haze remover. Facility 16 prints vehicle markings; Facility 25 prints appliance panel overlays, back-lit automotive panels, and store displays. During the four week demonstration period, Facility 16 reclaimed 55 screens although ink

remover was only used on seven screens and haze remover was only used on three screens; Facility 25 reclaimed 54 screens but the ink remover and haze remover were only used on about half of these. During the demonstrations, both Facility 16 and 25 used solvent-based inks.

Facility 16 reported that the ink remover left an unacceptable amount of ink on the screen and required a lot of physical effort. Facility 25 also reported that the ink remover was not acceptable, leaving ink residue on the screen, especially in the open areas of the screen mesh. The ink remover required much more time to apply (up to more than twice as long in some cases) with much greater physical effort than the products normally used at these facilities. Leaving the ink remover to sit for 3 - 5 minutes on the screen helped improve performance on the screen areas covered with emulsion, but did not help to remove the ink on the open screen areas.

Both facilities reported that the emulsion remover worked very well. Facility 16 was able to shorten the time between application and rinse from the recommended one or two minutes to less than one minute without compromising the product performance. Facility 25 improved the emulsion remover performance by wetting the screen before applying the emulsion remover.

Neither facility found the performance of the haze remover to be acceptable. They found the haze remover did not remove the ink haze left in the screen, which resulted in ghost images in future print jobs. Both facilities had to use their standard haze remover on their screens before they could be reused.

Alternative System Gamma Profile

The manufacturer recommends applying Product System Gamma as follows:

- Ink Remover Card up the excess ink. Spray both sides of the screen with the ink remover. Also spray a rag or brush with the product and rub both sides of the screen until all of the ink residue is completely dissolved or emulsified and the emulsion becomes clearly visible. Rinse well with water. For tests done at SPTF, a 1000 psi spray was used for rinsing the ink remover, emulsion remover, and haze remover.

- Emulsion Remover Scoop the emulsion remover out of the container and apply it to a brush. Use the brush to distribute the product evenly on both sides of the screen. After approximately two minutes spray out with a pressure washer. If no pressure water is available, brush until the photo emulsion is completely dissolved,and rinse out with a strong water spray. Should any ink residue remain, apply additional ink remover to the screen, brush it in for a few minutes until emulsified,then pressure rinse.

- Haze Remover Spray haze remover evenly on both sides of the screen. Distribute the product evenly using a nylon brush. Let sit for at least one hour. If the ink is dried, let it sit for up to 24 hours. Rinse off with water.

Alternative System Performance at SPTF

Product System Gamma was tested at SPTF on three screens (one with a solvent-based ink, one with a UV-curable ink, and one with a water-based ink). The ink remover performance

varied depending on the type of ink used. The emulsion remover and haze remover performance was consistent for all three screens. All products were applied according to the manufacturer's instructions.

On the screen with the solvent-based ink and the screen with UV ink, the ink remover dissolved the ink well with no effect on the stencil. On the water-based ink screen, however, heavy scrubbing and more product were needed to remove the ink. While scrubbing, the stencil started to break down in the half-tone area. For all the screens, only one rag was used for ink removal.

The emulsion remover easily dissolved the stencil with only light scrubbing on all three screens, leaving no ink or emulsion residue behind. The technician noted that most of the stencil dissolved while she was brushing, and the pressure wash took off the remainder. The screens did have a moderate ink stain remaining. Subsequent application of the haze remover lightened the ink stains so that a light to very light ink stain remained.

Alternative System Performance Details

Performance Details from Facility 16

Product System Gamma ink remover and haze remover did not work well and Facility 16 decided not to use these products during the demonstration period. The emulsion remover seemed to work very well; it was evaluated for the entire four-week demonstration period. During the demonstrations, there did not appear to be any change in the screen failure rate, or any noticeable effects on the screen mesh or frames.

The ink remover was only used to clean four screens. The printer sprayed the product on and let it sit for 30 second before wiping. In all cases it took a lot of effort to clean the screens. The ink remover left an oily film and an ink residue in the mesh. The facility decided to discontinue using the alternative ink remover based on these results.

The emulsion remover worked well, with no notable variations in performance among the screens used during the demonstration period. Although the product instructions require waiting 1 - 2 minutes after applying the product before pressure washing, the reclaimer found that the emulsion began to fall off the screen within 30 - 45 seconds after application. Screens were therefore pressure washed sooner than specified, with no noticeable effect on product performance. Facility 16 uses screens encompassing a large range of sizes, including some very large screens used for producing fleet markings for semi-trailers. The amount of emulsion remover used to clean the screens varied accordingly, although the results were consistent.

At this facility, the haze remover did not remove ghost images from the screens. After initial printing using the prescribed procedure, the screen reclaimer left the haze remover on a screen for 48 hours in an attempt to remove the ghost image, with no success. The facility had to use their regular haze remover on the screens in order to be able to reuse them in production. Use of the alternative haze remover was discontinued and the product was not included in the performance demonstration. For both the haze remover and the ink remover, an insufficient number of screens were reclaimed with these products to determine any correlations between demonstration conditions (e.g., number of impressions, ink color) and the product performance.

At Facility 16, one employee applied the ink remover, and a second reclaimed the screens and evaluated the printing quality on subsequent runs. Neither of these employees had direct

contact with the observer during the performance demonstration. Three different people served as the facility contact during the course of the study. The confusion of so many different contacts probably prevented the performance demonstration from being managed as closely as it was in other facilities.

Performance Details from Facility 25

Although all three components of System Gamma were used during part of the performance demonstrations, the ink remover and haze remover did not work well enough to be used for the complete four week period. The emulsion remover worked well and was used for the entire demonstration period. During the demonstrations, the printer did not notice any changes in the screen failure rate or any detrimental effects on the screen mesh, or frame.

The ink remover did not work well at Facility 25. It should be noted that the standard ink remover used at this facility is chemically very different from the alternative ink remover supplied as part of Product System Gamma. Adverse chemical interactions may have occurred on some of the older screens due to the differences in the chemicals, and may have affected all phases of the alternative system performance. The employee who used the alternative ink remover tried several different procedures in order to improve the performance such as using presoaked rags to get more ink remover on the screen, waiting 3 - 5 minutes after application before wiping the ink, and laying rags soaked in ink remover over the screen as soon as it came off the press. Although these procedures helped remove the ink from the stencil surface, there was still a large amount of ink left in the screen; enough to completely block the mesh in some cases. The residual ink was not removed by the emulsion and haze removal steps. The facility used the alternative ink remover for a week and a half before they had to stop because of the poor performance. None of the screens cleaned with this alternative product worked well in production, so they all had to be reprocessed with the facility's regular products before acceptable printing quality was achieved. The facility used several different solvent ink systems and, in reviewing the data from the printer's observations, the ink system and the length of the ink drying time seemed to be the most influential variable in determining the level of performance of the alternative system. However, the ink remover performance was not acceptable for any of the ink systems used.

The emulsion remover performed consistently well on all screens and stencils. The reclaimer found that the product acted faster on the stencil if the screen was wetted before applying the emulsion remover.

The haze remover did not work well. The haze remover was allowed to react on the screens as long as 24 hours, without successfully removing the ink haze. The reclaimer continued to use the haze remover after use of the ink remover was suspended, to see if it would perform better if the haze was less severe. She found that the haze remover worked better if the screens were dried before the product was applied. Even so, too much ink haze was left in the screens to be able to successfully reuse them. Ink residue left in the mesh caused ghost images in subsequent jobs, and eventually solubilized in similar ink systems, which caused the inks to become discolored during the printing runs. Facility 25, therefore, discontinued the use of the alternative haze remover after the second week of demonstrations.

At Facility 25, printing quality judgements were made by the printer, along with the other employees involved in the study. The personnel involved seemed to work hard to try to get acceptable results from the products.

Alternative System Performance Table Compiled from Field Sites

The following table highlights the performance of the product system as recorded by the printers using the products at the demonstration facilities. In addition to the field demonstration performance data, results of the product tests performed at SPTF are also summarized in this table. More descriptive information on the demonstration facilities is included in Section 6.

Facility Profiles

General Facility Background for Facility 16

Facility 16 prints fleet vehicle markings on vinyl film. Their typical run length is 200 sheets, and approximately 60% of their orders are repeat orders. There are over 50 employees at this location, and 7 - 10 are involved in ink removal and 1 - 3 are involved in screen reclamation. For the performance demonstrations, all inks used were solvent-based on polyester or monoflex screens with capillary film emulsions. Screens mesh counts of 200 - 390 threads/inch were used for the demonstrations. Average screen size at this facility is 12 ft^2 and approximately 20 screens are reclaimed daily.

Screen Reclamation Area in Facility 16

After initial ink removal at the press, the remainder of the ink is removed in the same washout booth as is used for emulsion and haze removal. The reclamation area is 50 - 100 ft^2 and is ventilated via the facility-wide system. The average temperature during the observer's visit was 68°F (and 62% relative humidity). Spent solvent and ink waste are sent off-site to a recycler.

Current Screen Reclamation Products at Facility 16

Information on the chemical composition of the standard ink remover at this facility was not available for this document. For emulsion removal, they use a proprietary aqueous mixture with at least sodium periodate. Their haze remover is a formulation which contains 100% sodium periodate.

Current Screen Reclamation Practices in Facility 16

Using their standard products, this facility reclaims their screens following the procedure described below. Gloves are worn during ink removal, and during emulsion and haze removal gloves, eye protection, aprons, and respiratory protection are available as personal protective equipment for the operators.

- Ink Remover: Card off the excess ink. At the press, apply press wash to a disposable wipe from a safety can and wipe down the screen. Bring the screen to the washout booth. Apply ink remover to both sides of the screen from a bucket with a brush. Wait for one minute, then rinse with a high pressure (2000 psi) spray. Remove the tape from the screen edges and rinse again with the high pressure washer.

- Emulsion Remover: Dip a brush in the container of emulsion remover and brush it into both sides of the screen. Rinse with the high pressure wash and let the screen dry before applying the haze remover.

Table V-131
On-Site Performance Summary For Alternative System Gamma

		Performance						Demonstration Conditions			
	System Component	Avg Drying Time Before Using Product	Average Quantity Applied	Average Cleaning Time	Avg Effort Req'd	Performance for Each System Component	Overall System Performance	Ink type(s)	Emulsion type	Mesh type; Thread count	Average Screen Size
In-field Demonstrations at Volunteer Printing Facilities											
Facility 16	*Ink remover*	3.0 ± 2.4 mins (n=7)	5.0 ± 2.0 oz. (n=7)	11.1 ± 6.6 mins (n=7)	Med	Ink and oily residue left in mesh.	• Did not use the ink remover or haze remover due to poor performance.	Solvent-based	Capillary film	Polyester, untreated or abraded; 200 - 390 threads/ inch	2294 in^2
	Emulsion Remover	52.4 ± 272.0 mins (n=55)	2.3 ± 1.3 oz. (n=51)	1.8 ± 1.8 mins (n=50)	Low	Easily removed stencil on all screens.					
	Haze Remover	0.0 ± 0.0 mins (n=55)	3.3 ± 1.5 oz. (n=3)	3.0 ± 0.0 mins (n=1)	Med	Did not remove ghost images.					
Facility 25	*Ink Remover*	19.2 ± 15.0 mins (n=23)	10.8 ± 4.6 oz. (n=22)	11.7 ± 5.2 mins (n=22)	High	Excessive ink residue left in screen.	• Stopped using ink remover and haze remover after 2 weeks due to poor results.	Solvent-based	Direct photo stencil	Polyester, no treatment or abraded; 175 - 420 threads/ inch	1848 in^2
	Emulsion Remover	13.2 ± 31.1 hrs (n=54)	1.2 ± 0.4 oz. (n=50)	3.0 ± 0.3 mins (n=50)	Low	Quickly, easily removed stencil.					
	Haze Remover	4.6 ± 11.8 hrs (n=54)	5.3 ± 7.2 oz. (n=23)	2.2 ± 0.4 mins (n=12)	Low	Ink haze remained in screen.					

Table V-132
Laboratory Performance Summary For Alternative System Gamma

		Performance						Demonstration Conditions			
	System Component	Avg Drying Time Before Using Product	Average Quantity Applied	Average Cleaning Time	Avg Effort Req'd	Performance for Each System Component	Overall System Performance	Ink type(s)	Emulsion type	Mesh type; Thread count	Average Screen Size
Laboratory Testing at SPTF											
SPTF Solvent-based Ink	*Ink Remover*	15 mins	1.5 oz.	3.8 mins	Low	Ink dissolved well. No effect on stencil.		Solvent-based	Dual cure direct	Polyester; 260 threads/ inch	360 in^2
	Emulsion Remover	24 hours	1.0 oz.	3.9 mins	Low	Removed stencil easily. Moderate ink stain remaining.					
	Haze Remover	0 mins	1.0 oz.	1.8 mins	Low	Lightened stain.					
SPTF UV-curable Ink	*Ink Remover*	15 mins	1.5 oz.	3.5 mins	Low	Ink dissolved well. No effect on stencil.		UV-curable	Dual cure direct	Polyester; 390 threads/ inch	360 in^2
	Emulsion Remover	24 hours	1.5 oz.	4.8 mins	Low	Removed stencil easily. Moderate ink stain remaining.					
	Haze Remover	0 mins	0.5 oz.	1.8 mins	Low	Lightened stain.					
SPTF Water-based Ink	*Ink Remover*	15 mins	2.0 oz.	5.8 mins	Med	Heavy scrubbing required to dissolve ink. Parts of stencil deteriorated.		Water-based	Dual cure direct	Polyester; 260 threads/ inch	360 in^2
	Emulsion Remover	24 hours	1.0 oz.	4.8 mins	Low	Removed stencil easily. Moderate ink stain remaining.					
	Haze Remover	0 mins	1.0 oz.	2.0 mins	Low	Lightened stain.					

- Haze Remover: Dip a brush into the haze remover and apply the product to both sides of the screen. Allow the screen to air dry. Rinse the screen with the high pressure sprayer.

General Facility Background for Facility 25

Facility 25 prints point-of-purchase displays and overlays for appliances and automotive applications. Print runs at this facility average 16 hours and approximately 80% of their orders are repeat orders. During the Performance Demonstration, this facility used solvent-based inks and a direct photo stencil on polyester screens with mesh counts of 175 - 420 threads per inch. The most common screen sizes at Facility 25 are 42 inches x 42 inches and 42 inches x 50 inches. Approximately 25 screens are reclaimed daily.

Screen Reclamation Area in Facility 25

Ink removal is done at the press and screen reclamation is done in a separate reclaim room. At the press, the facility-wide system provides ventilation for the area. A local, mechanical system over the spray booth ventilates the screen reclamation area. During the observer's visit, the average temperature in the facility was 68°F (and 34% relative humidity). Spent solvent waste is recycled both on-site and off-site, and recycled product is reused in the facility. Ink waste is disposed of as hazardous waste. Waste water from the washes of the emulsion remover and haze remover is not recycled or filtered at this facility.

Current Screen Reclamation Products at Facility 25

This facility's standard ink remover is a solvent blend which includes the following chemicals: cyclohexanone (<60%), xylenes (<5%), ethyltoluene (<15%), trimethylbenzenes (<35%), C-10 aromatics (<5%), and cumene (<5%). They also use another solvent blend which contains methyl ethyl ketone (<35%), toluene (<55%), n-butyl acetate (<20%), and heptane (<15%). Their emulsion remover is either a proprietary aqueous mixture with at least periodate salt (<10%), or a proprietary aqueous mixture with at least an acid salt. For haze removal, this facility uses a proprietary aqueous mixture with at least sodium hydroxide (<15%).

Current Screen Reclamation Practices in Facility 25

During the screen reclamation process at Facility 25, personal protective equipment available to the employees includes gloves, eye protection, aprons, and ear protection. Screens are reclaimed as follows:

- Ink Remover: At the press, card off excess ink. To remove the ink, rub the screen with wipes that are saturated in ink remover. Approximately 6 - 8 wipes are used for each screen.

- Emulsion Remover: Wet the screen with the hose to soften the blockout. Spray emulsion remover onto both sides of the screen and let sit for 30 seconds. Rinse from the bottom to the top of the screen with a high pressure wash (2500 psi)followed by a low pressure wash.

- Haze Remover: Allow the screen to air dry before applying the haze remover. Dip a brush in the haze remover and rub into screen. Wait for one minute. Rinse with a high pressure spray. Vacuum dry the screen.

Cost

Table V-133
Method 2: Summary of Cost Analysis for Alternative System Gamma

Cost Element Description		Baseline (Traditional System 4)	Alternative System Gamma	
			Facility 16	Facility 25
Facility Characteristics				
Average screen size (in^2)		2,127	2,294	1,848
Average # screens/day		6	20	25
Cost Elements per Screen				
Labor	Time spent applying, scrubbing, and removing reclamation products (min)	24.4	15.9	16.9
	Cost ($)	5.33	3.48	3.70
Materials and Equipment	# of rags used	3	5.0	7.0
	Cost ($)	0.45	0.75	1.04
Reclamation Product Use	Ink Remover Average Volume (oz.)	8.0	5.0	10.8
	Cost ($)	0.22	0.43	0.92
	Emulsion Remover Average Volume (oz.)	3.5	2.3	1.2
	Cost ($)	0.13	0.24	0.12
	Haze Remover Average Volume (oz.)	3.0	3.3	5.3
	Cost ($)	0.12	0.24	0.39
Hazardous Waste Disposal	Amount (g)	34	0	0.0
	Cost ($)	0.02	0	0.0
Totals				
Total Cost ($/screen)		6.27	5.14	6.17
Normalized[a]		6.27	5.06	5.61
Total Cost ($/year)		9,399	25,708	38,547
Normalized[a]		9,399	7,590	8,417

[a]Normalized values adjust product usage, number of screens cleaned, and number of rags laundered at demonstration facilities to reflect the screen size and number of screens cleaned per day under the baseline scenario. Labor costs, however, are not normalized. Normalization allows a comparison between the baseline and facility results.

Note: For additional information regarding product performance see performance demonstration summaries.

Product System Mu

Formulation

Ink Remover	Dibasic esters
	Methoxypropanol acetate
	d-Limonene
	Ethoxylated nonylphenol
	Derivatized plant oil
Emulsion Remover	Periodic acid
	Water
Haze Remover	Sodium hypochlorite
	Alkali/Caustic
	Sodium alkyl sulfate
	Water

Occupational Exposure

Table V-134
Occupational Exposure Estimates for Alternative System Mu System

System	Inhalation (mg/day)				Dermal (mg/day)	
	I	II	III	IV	Routine	Immersion
Ink Remover						
Dibasic esters	3	0	0	0.2	1014	4728
Methoxypropanol acetate	31	0.4	0	1.7	312	1460
Limonene	21	0.6	0	2.4	156	728
Ethoxylated nonylphenol	0	0	0	0	94	437
Derivatized plant oil	0	0	0	0.2	62	291
Emulsion Remover						
Periodic acid	0	0	0	0	156	728
Water	0	0	0	0	1400	6550
Haze Remover						
Sodium hypochlorite	0	0	0	0	585	2730
Alkali/Caustic	0	0	0	0	39	182
Water	0	0	0	0	827	3860
Sodium alkyl sulfate	0	0	0	0	109	510

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry

Table V-135
Occupational Risk Estimates for Alternative System Mu

Name	Hazard Quotient[b]			Margin Of Exposure[a]					
		Dermal		Inhalation		Dermal			
						Routine		Immersion	
	Inhalation	Routine	Immersion	NOAEL[c]	LOAEL[d]	NOAEL	LOAEL	NOAEL	LOAEL
Mu - Ink Remover									
Dibasic esters	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methoxypropanol acetate	0.8	7.4	35	NA	600	NA	NA	NA	NA
Limonene	NA	NA	NA	NA	432	NA	67	NA	14
Ethoxylated nonylphenol	NA	NA	NA	NA	NA	NA	NA	NA	NA
Derivatized plant oil	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mu - Emulsion Remover									
Periodic acid	NA	NA	NA	NA	NA	NA	NA	NA	NA
Water	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mu - Haze Remover									
Sodium hypochlorite	NA	NA	NA	NA	NA	NA	NA	NA	NA
Alkali/Caustic	NA	NA	NA	NA	NA	NA	NA	NA	NA
Water	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium lauryl sulfate	NA	NA	NA	300	NA	190	NA	41	NA

[a]Margin of Exposure (MOE) values above 100 for a NOAEL and 1000 for a LOAEL indicate low risk.
[b]Hazard Quotient is the ratio of the estimated chronic dose/exposure level to the Reference Dose (RfD) or the Reference Concentration (RfC). Hazard Quotient values less than 1 imply that adverse effects are very unlikely to occur.
[c]NOAEL means No Observed Adverse Effect Level.
[d]LOAEL means Lowest Observed Adverse Effect Level.

Occupational Risk Conclusions and Observations

Ink Remover and Haze Remover

- Concerns exist for chronic risks from both inhalation and dermal exposures to *d*-limonene during ink removal based on the calculated margins-of-exposure.

- Hazard quotient calculations for methoxypropanol acetate used in ink removal indicate a marginal concern for chronic dermal exposures and low concern for chronic inhalation exposures.

- Margin-of-exposure calculations show possible concerns for developmental toxicity risks from inhalation exposures to methoxypropanol acetate.

- Developmental and chronic toxicity risks from dermal exposures to sodium alkyl sulfate in haze remover are very low based on the calculated margin of exposure.

- Risks from other ink remover and haze remover components could not be quantified because of limitations in hazard data, although dermal exposures to all components could be relatively high.

Emulsion Removers (All Systems)

- All of the systems that employ an emulsion remover use either a strong oxidizer such as hypochlorite or periodate or a strong base such as sodium hydroxide. The haze removers in Alpha, Epsilon, Gamma, Mu, Omicron, and Theta also contain these compounds. All of these materials present a high concern for skin and eye irritation and tissue damage if workers are exposed in the absence of proper protective clothing. None of the emulsion removers present significant inhalation risks.

Environmental Releases

Table V-136
Environmental Release Estimates in Screen Cleaning Operations
Method 2, Alternative System Mu

System	Release Under Each Scenario (g/day)						
	I			II	III	IV	
	air	water	land	air	air	air	water
Ink Remover							
Dibasic esters	5.1	0	446	0	0	0.3	877
Methoxypropanol acetate	64	0	75	0.8	0.5	3.6	266
Limonene	43	0	27	1.2	0.7	5.1	130
Ethoxylated nonylphenol	0	0	42	0	0	0	81
Derivatized plant oil	0.3	0	27	0.1	0	0.3	54
Emulsion Remover							
Periodic acid	0	62	0	0	0	0	0
Water	0	559	0	0	0	0	0
Haze Remover							
Sodium hypochlorite	0	200	0	0	0	0	0
Alkali/Caustic	0	13	0	0	0	0	0
Water	0	282	0	0	0	0	0
Sodium alkyl sulfate	0	37	0	0	0	0	0

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry

Table V-137
Summary of Estimated Daily Environmental Releases from a Hypothetical Facility Using Screen Reclamation Method 2, Alternative System Mu

Substance:	To Air:	To Water:	To Landfill:
Dibasic esters	5.4 g/day	877 g/day at laundry	446 g/day
Methoxypropanol acetate	68.9 g/day	266 g/day at laundry	75 g/day
Limonene	50 g/day	130 g/day at laundry	27 g/day
Ethoxylated nonylphenol		81 g/day at laundry	42 g/day
Derivatized plant oil	0.7 g/day	54 g/day at laundry	27 g/day
Periodic acid		62 g/day	
Sodium hypochlorite		200 g/day	
Alkali/caustic		13 g/day	
Sodium alkyl sulfate		37 g/day	

Releases to Water from a Single Facility

Table V-138
Estimated Releases to Water from Traditional Formulations from Screen Reclamation at a Single Facility Using Screen Reclamation Method 2, Alternative System Mu

Substance	Amount Released to Water from Facility	Waste water Treatment Removal Efficiency	Amount to Water After Waste water Treatment	Daily Stream Concentration, ug/L[a] for 1000 MLD Receiving Water
Dibasic esters	877 g/day at laundry	84-97 %	42.5 g/day	5×10^{-2}
Methoxypropanol acetate	266 g/day at laundry	97 %	8 g/day	8×10^{-3}
Limonene	130 g/day at laundry	> 99 %	<1.3 g/day	$<1 \times 10^{-3}$
Ethoxylated nonylphenol	81 g/day at laundry	100 %	0	0
Derivatized plant oil	54 g/day at laundry	100 %	0	0
Periodic acid	62 g/day	100 %	0	0
Sodium hypochlorite	200 g/day	100 %	0	0
Alkali/caustic	13 g/day	100 %	0	0
Sodium alkyl sulfate	37 g/day	100 %	0	0

[a]ug/L is Micrograms per liter, which is parts per billion for a substance in water. MLD is Million liters per day.

Releases to Air from Individual Screen Printing Facilities

Table V-139
Air Release, Concentration and Potential Dose Estimates from a Single Model Facility Using Screen Reclamation Method 2, Alternative System Mu

Substance	Amount of Releases per day	Highest Average Concentration 100 M away	Annual Potential Dose, mg/year[a]
Dibasic esters	5.4 g/day	1.1×10^{-2} ug/m^3	8×10^{-2}
Methoxypropanol acetate	68.9 g/day	1.4×10^{-1} ug/m^3	1
Limonene	50 g/day	1×10^{-1} ug/m^3	7×10^{-1}
Derivatized plant oil	0.7 g/day	1.4×10^{-3} ug/m^3	1×10^{-2}

[a]This estimates doses for people living 100 Meters from the hypothetical facility. The actual number of people who would fall into this range can be determined from census data, if the facility location is known. The model used to calculate concentrations is more completely explained in the Overview by Media-Air Section in Chapter III. To calculate the annual potential dose, the concentration is multiplied by the amount a person will breathe (20 m^3/day) and the number of days per year (365), and the units are converted to mg/year by dividing by 1000.

General Population Risk Conclusions and Observations

- Health risks to the general population from both air and water exposures are very low for Method 2, Product System Mu.

Although air releases were evaluated for only a single facility, it is very unlikely that an analysis of cumulative air releases would lead to different risk conclusions. Examples of general population exposure and risk estimates are shown for Method 2, Traditional System 1 in Methods 1 and 2 and Alternative System Chi in Method 2; please reference these sections as illustrative examples. Hazard Quotient values below one indicate very low risk. Margin-of-Exposure (MOE) values above 100 for a NOAEL or above 1000 for a LOAEL indicate very low risk.

Ecological Risks From Water Releases Of Screen Reclamation Chemicals

- None of the single facility releases of Method 2, product System Mu reach an ecotoxicity concern concentration.

Performance

General Summary of Product System Mu Performance, and Related Variables

This product system consisted of an ink remover, an emulsion remover, and a haze remover. The performance of the product system was demonstrated at Facilities 17 and 22. Facility 17 prints decals; Facility 22 prints back-lit automotive overlays. During the four week demonstration period, Facility 17 reclaimed 18 screens and Facility 22 reclaimed 44 screens.

For the performance demonstrations, Facility 17 used primarily UV-cured inks, and Facility 22 used solvent-based inks.

Facility 17 reported that the ink remover worked well, although black (UV-cured) inks were more difficult to remove than the other UV-cured inks. Facility 22 reported that the ink remover performance was unacceptable for their solvent-based ink system. Extra physical effort and time were needed, and a lot of product was applied, but an ink residue still remained on the screen. The standard ink remover used at Facility 22 is chemically very different from the alternative ink remover supplied as part of Product System Mu. These differences may have caused adverse chemicals interactions on older screens.

The emulsion remover performance was very good at both facilities. It removed the emulsion quickly, easily, and completely. Facility 22 commented that the emulsion remover performance was "excellent."

Facility 17 reported that the haze remover worked better and faster than one of their usual products, but not as well as the haze remover that they use for difficult stains. The haze remover's performance was also affected by the number of impressions in the previous test run: it did not work as well after runs with many impressions. Facility 22 reported that the haze remover did not work at all and they had to use their standard product before they could reuse the screen. There was no visible change in the haze when the haze remover was applied.

Alternative System Mu Profile

The manufacturer recommends applying Product System Mu as follows:

- Ink Remover Card up the excess ink. Spray both sides of the screen with the ink remover. Also spray a rag or brush with the product and rub both sides of the screen until all of the ink residue is completely dissolved or emulsified and the emulsion becomes clearly visible. Rinse well with water. For tests done at SPTF, a 1000 psi spray was used for rinsing the ink remover, emulsion remover, and haze remover.

- Emulsion Remover Using a spray bottle, apply the emulsion remover to both sides of the screen. Distribute the product evenly with a brush and scrub the screen gently for approximately two minutes. Rinse thoroughly with a high pressure water spray.

- Haze Remover Spray haze remover evenly on both sides of the screen. Distribute the product using a nylon brush. Let sit for at least one hour. If the ink is dried, let it sit for up to 24 hours. Rinse off with water. If stains remain in the screen, allow the screen to dry and repeat the application procedure for the ink remover and pressure rinse.

Alternative System Performance at SPTF

Product System Mu was tested at SPTF on three screens (one with a solvent-based ink, one with a UV-curable ink, and one with a water-based ink). The ink remover and the haze remover performance varied depending on the type of ink used. The emulsion remover and the haze remover performance was consistent on all three screens.

On the screen with the solvent-based ink and the screen with UV ink, the ink remover dissolved the ink easily with little scrubbing and no effect on the emulsion. On the water-based ink screen, however, the ink dried in the screen and heavy scrubbing and more product were needed to remove the ink. While scrubbing, the stencil started to break down in the half tone area. For all three screens, one wipe was used to remove the ink.

The emulsion remover easily dissolved the stencil with only light scrubbing on all three screens, leaving no ink or emulsion residue behind. The screens did have a light-to-moderate ink stain was remaining. Subsequent application of the haze remover lightened the ink stains of the UV ink and the water-based ink screen, so that a very light ink stain remained. The haze remover did not lighten the moderate ink stain on the screen with the solvent-based ink.

Alternative System Performance Details

Performance Details from Facility 17

Facility 17 thought that Product System Mu cleaned the screens well and the screen reclaimer noted that the odors associated with the alternative system were not as bad as those produced by the facility's usual products.

The ink remover performed well. Compared to their standard product, the reclaimer noted that when using the alternative ink remover, he did not have to scrub the screens as much and did not have to use as much product to get the screens clean. The printer commented that it was more difficult to remove all of the ink from the screen when the previous print run was a long one. However, the data, although limited, do not show a change in the ink remover quantity or time corresponding to a change in the length of the previous run. Black UV-cured inks were not removed as effectively as other UV-cured ink colors.

The emulsion remover performance was very good on all screens. The haze remover worked well in most cases, except when the haze was unusually dark. This facility normally uses two haze removers: one is a weaker chemical that is used more frequently and the other, stronger chemical, is only used for stubborn stains. The Product System Mu haze remover worked better than the weaker of their two usual haze removal products, but not as well as the stronger chemical. On the one screen they reclaimed that had solvent-based ink on it, the alternative haze remover did not remove the haze and the printer had to use their stronger haze remover to clean the screen. All other screens reclaimed had been used with UV ink, and on these screens, the facility felt that the alternative haze remover performed as well as and more quickly than the weaker of their two haze removers.

Using the alternative system did not substantially change the screen cleaning routine at this facility. The printer did not notice any changes in the screen condition during the time the alternative system was in use. If less scrubbing is associated with the use of the alternative system, then screen abrasion and possibly the screen failure rate could decrease with continued use of the alternative system.

Performance Details from Facility 22

This facility found the performance of Product System Mu ink remover and haze remover was not acceptable. The printer thought the emulsion remover performance was very good.

The ink remover was applied to the screens immediately after completion of the press runs. Cleaning the screens still took a high level of effort and a long time to accomplish. All

screens took at least 20 minutes to clean, and two screens took 60 minutes. Screen cleaning required 10 - 16 ounces of product; because of the large quantity required, the facility ran out of ink remover after cleaning the twentieth screen. Even with this extra effort, and extra product, an ink residue remained on the screens. The ink remover was especially ineffective on ink which built up partially dried on the edge of the screen during long runs. Overall, the facility contact commented that the product did not seem to cut the ink at all. It should be noted that the standard ink remover used by this facility contains strong hydrocarbon solvents and is chemically very different from the alternative ink remover. These chemical differences may have led to an adverse chemical interaction.

The emulsion remover worked well, with no notable variations in performance among the screens used. It required a low level of effort, and consistently removed all the emulsion from the screens. The performance of the haze remover proved to be unacceptable at Facility 22. Ghost images were not removed from the screens and the facility was not able to reuse the screens until they were treated with their standard haze remover. For this reason, use of the alternative haze remover was suspended during the first week of the demonstration.

At Facility 22 the facility contact, who was the product development manager, removed the ink, reclaimed the screens and evaluated the printing quality on subsequent runs. Although these were not tasks he usually performs, it should have ensured consistency of judgement on the product performance evaluations. Product System Mu did not appear to cause screen failure, or have any noticeable effects on the screens or frames.

Alternative System Performance Table Compiled from Field Sites

The following table highlights the observed performance of the product system and the relevant conditions of the demonstration, as recorded by the printers using the products at the demonstration facilities. In addition to the field demonstration performance data, results of the product tests performed at SPTF are also summarized in this table. More descriptive information on the demonstration facilities is included in the section following the table.

Facility Profiles

General Facility Background for Facility 17

Facility 17 prints decals on paper, plastics, metals, ceramics, and glass. Their typical run length is 400 impressions, and approximately 5% of their orders are repeat orders. There are about 5 employees at this location, and 1 - 3 are involved in screen reclamation. Both solvent-based and UV-curable ink systems are used at this facility; primarily UV inks were used during the performance demonstrations. Screens with mesh counts of 280 - 390 threads/inch and direct photo stencils were used for the demonstrations. The average screen size at this facility is 16 ft^2 and approximately 25 screens are reclaimed daily.

Screen Reclamation Area in Facility 17

Ink removal is done at the press where local ventilation is provided. Emulsion and haze removal are done in a sink in the screen reclamation area, which is approximately 150 ft^2 and is ventilated via a hood above the sink. The average temperature during the observer's visit was 70°F (and 41% relative humidity). Spent solvent and ink waste are disposed of as hazardous waste. Waste water from the high-pressure wash of the emulsion remover and haze remover is not recycled or filtered at this facility.

Table V-140
On-Site Performance Summary For System Mu

	System Component	Performance						Demonstration Conditions			
		Avg Drying Time Before Using Product	Average Quantity Applied	Average Cleaning Time	Average Effort Required	Performance for Each System Component	Overall System Performance	Ink type(s)	Emulsion type	Mesh type; Thread count	Average Screen Size
In-field Demonstrations at Volunteer Printing Facilities											
Facility 17	*Ink remover*	13.9 ± 16.9 hrs (n=19)	2.7 ± 0.7 oz. (n=18)	7.0 ± 3.9 mins (n=19)	Moderate	Removed ink well.	• Haze remover required at least one hour of wait time. • All screens with UV ink were reusable.	UV ink (one screen with solvent-based ink)	Direct photo stencil	Mesh type not recorded; 280 - 390 threads/inch	2270 in^2
	Emulsion Remover	4.9 ± 1.7 hrs (n=19)	2.6 ± 0.6 oz. (n=18)	5.7 ± 2.0 mins (n=19)	Low	Removed stencil easily.					
	Haze Remover	21.3 ± 10.5 mins (n=19)	2.9 ± 0.7 oz. (n=18)	data not recorded	Moderate	Worked well on moderate haze.					
Facility 22	*Ink Remover*	15.6 ± 12.6 mins (n=20)	11.6 ± 1.4 oz. (n=20)	30.5 ± 12.0 mins (n=20)	High	Left ink residue in the screen.	• Used their standard haze remover before reusing screens. • Emulsion remover worked better than any other they tried.	Solvent-based	Direct photo stencil	Mono-filament polyester; 230 - 305 threads/inch	1520 in^2
	Emulsion Remover	22.5 ± 72.5 hrs (n=47)	1.1 ± 0.3 oz. (n=47)	2.8 ± 0.5 mins (n=47)	Low	Removed stencil easily.					
	Haze Remover	2.2 ± 1.2 mins (n=47)	1.3 ± 0.5 oz. (n=6)	1.3 ± 0.6 mins (n=3)	Moderate	Left ghost image in screens.					

Table V-141
Laboratory Performance Summary For System Mu

	System Component	Performance						Demonstration Conditions			
		Avg Drying Time Before Using Product	Average Quantity Applied	Average Cleaning Time	Average Effort Required	Performance for Each System Component	Overall System Performance	Ink type(s)	Emulsion type	Mesh type; Thread count	Average Screen Size
Laboratory Testing at SPTF											
SPTF Solvent-based Ink	*Ink Remover*	15 mins	1.0 oz.	3.5 mins	Low	Dissolved ink easily.		Solvent-based	Dual cure direct	Polyester; 260 threads/inch	360 in^2
	Emulsion Remover	24 hours	0.5 oz.	3.6 mins	Med	Dissolved stencil well. Moderate ink stain remaining.					
	Haze Remover	0 mins	1.0 oz.	2.0 mins	Low	Haze remover did not lighten ink stain.					
SPTF UV-curable Ink	*Ink Remover*	15 mins	1.5 oz.	2.9 mins	Low	Dissolved ink very easily.		UV-curable	Dual cure direct	Polyester; 390 threads/inch	360 in^2
	Emulsion Remover	24 hours	1.0 oz.	3.3 mins	Med	Dissolved stencil well. Light ink stain remaining.					
	Haze Remover	0 mins	0.5 oz.	2.0 mins	Low	Lightened ink stain.					
SPTF Water-based Ink	*Ink Remover*	15 mins	2.0 oz.	6.1 mins	High	Excessive scrubbing and product required to remove dried ink.		Water-based	Dual cure direct	Polyester; 260 threads/inch	360 in^2
	Emulsion Remover	24 hours	1.5 oz.	3.1 mins	Med	Dissolved stencil well. Light ink stain remaining.					
	Haze Remover	0 mins	0.5 oz.	2.0 mins	Low	Lightened ink stain.					

Current Screen Reclamation Products at Facility 17

The standard ink remover used at Facility 17 is a proprietary blend consisting of at least propylene glycol ethers (<50%). Their emulsion remover is a proprietary aqueous mixture which contains periodate salt (<10%). For haze removal, they use a proprietary aqueous mixture with sodium hydroxide (<15%).

Current Screen Reclamation Practices in Facility 17

Using their standard products, this facility reclaims their screens following the procedure described below. Gloves, eye protection, aprons, respiratory protection, and barrier cream are available as personal protective equipment for the operators during screen reclamation activities.

- Ink Remover: Card off the excess ink. At the press, spray press wash onto the screen and wipe with reusable rags. Repeat if necessary. One or two rags are used for each screen. Bring the screen to the reclamation sink and spray the ink remover onto both sides of the screen from a low pressure (60 psi) sprayer. Rub the product into the screen with a brush, then pressure rinse (1200 psi) the screen.

- Emulsion Remover: Spray the emulsion remover onto both sides of the screen from a low pressure sprayer. Brush the emulsion remover into the screen. Pressure rinse and allow to air dry.

- Haze Remover: This facility uses two haze remover products. The weaker chemical is used for light to moderate stains. The stronger product is used only when the haze is dark. For light to moderate haze, spray the screen with the haze remover and let it sit for about 30 minutes. Scrub both sides of the screen for about one minute each and rinse with the pressure washer. Give the screen a final rinse at low pressure from a hose. For dark haze, coat both sides of the screen with the haze remover using the scoop coater (this is the same kind of coater that is used when applying emulsion to the screen and it applies a thin, even coat). Let sit for 3 - 4 minutes. Pressure wash both sides of the screen.

General Facility Background for Facility 22

Facility 22 prints back-lit automotive graphic overlays on plastics. Typically, they print about 500 sheets per run and approximately 90% of their orders are repeat orders. There are approximately 40 employees at this facility, and two people are involved in screen reclamation. During the Performance Demonstration, this facility used solvent-based inks and a direct photo stencil. Polyester screens with mesh counts of 230 - 305 threads per inch were used. The average screen size in this facility is 40 inches x 40 inches and approximately 12 screens are reclaimed daily.

Screen Reclamation Area in Facility 22

Ink removal is done both at the press and in the screen reclamation room. At the press, the plant system (facility-wide) provides ventilation. In the screen reclamation area, there is a back-lit spray booth and the area is ventilated by a fan in the hood of the booth. During the observer's visit, the average temperature in the facility was 68°F (and 44% relative humidity). Ink waste is disposed of as hazardous waste and rags are disposed of as non-hazardous waste.

Waste water from the washes of the emulsion remover and haze remover is not recycled or filtered at this facility.

Current Screen Reclamation Products at Facility 22

For ink removal, Facility 22 uses a custom solvent blend which consists of ethyl acetate (20% - 27%), methyl ethyl ketone (20%), and xylene (20%). As an emulsion remover, they use a proprietary aqueous mixture with at least sodium periodate. Their standard haze remover is a proprietary blend which consists primarily of tripropylene glycol methyl ether.

Current Screen Reclamation Practices in Facility 22

During the screen reclamation process at Facility 22, personal protective equipment available to the employees includes gloves, eye protection, and ear protection. Screens are reclaimed as follows:

- Ink Remover: At the press, card off excess ink and wipe the screen with rags that are saturated in ink remover. Bring the screen to the screen reclamation room. Saturate disposable wipes in the ink remover and wipe both sides of the screen. Four to six wipes are used on each screen. Rinse the screen with a high pressure washer (2000 psi).

- Emulsion Remover: Spray both sides of the screen with the emulsion remover. Wipe the screen with a scrubber pad. Rinse with a high pressure wash. If needed, spray on more product, brush and rinse again.

- Haze Remover: Dip a disposable wipe in the haze remover container and wipe both sides of the screen. Rub the product into the stained areas with a brush. Rinse with a high pressure wash on both sides, followed by a final, low pressure rinse with the hose. Vacuum dry the screen.

Cost

Table V-142
Method 2: Summary of Cost Analysis for Alternative System Mu

Cost Element Description		Baseline (Traditional System 4)	Alternative System Mu	
			Facility 17	Facility 22
Facility Characteristics				
Average screen size (in^2)		2,127	2,270	1,520
Average # screens/day		6	25	12
Cost Elements per Screen				
Labor	Time spent applying, scrubbing, and removing reclamation products (min)	24.4	17.2	34.6
	Cost ($)	5.33	3.75	7.58
Materials and Equipment	# of rags used	3	1.0	10.8
	Cost ($)	0.45	0.15	1.61
Reclamation Product Use	Ink Remover Average Volume (oz.)	8.0	2.7	11.6
	Cost ($)	0.22	0.16	0.70
	Emulsion Remover Average Volume (oz.)	3.5	2.6	1.1
	Cost ($)	0.13	0.21	0.09
	Haze Remover Average Volume (oz.)	3.0	2.9	1.3
	Cost ($)	0.12	0.17	0.08
Hazardous Waste Disposal	Amount (g)	34	110	73
	Cost ($)	0.02	0.08	0.05
Totals				
Total Cost ($/screen)		6.27	4.53	10.11
Normalized[a]		6.27	4.79	9.33
Total Cost ($/year)		9,399	28,295	30,338
Normalized[a]		9,399	7,185	13,997

[a]Normalized values adjust product usage, number of screens cleaned, and number of rags laundered at demonstration facilities to reflect the screen size and number of screens cleaned per day under the baseline scenario. Labor costs, however, are not normalized. Normalization allows a comparison between the baseline and facility results.

Note: For additional information regarding product performance see performance demonstration summaries.

Product System Phi

Formulation

Ink Remover	Dibasic esters
Emulsion Remover	Sodium periodate
	Water
	Ethoxylated nonylphenol
	Other
Haze Remover	N-methyl pyrrolidone
	Dibasic esters

Occupational Exposure

Table V-143
Occupational Exposure Estimates for Alternative System Phi

System	Inhalation (mg/day)				Dermal (mg/day)	
	I	II	III	IV	Routine	Immersion
Ink Remover						
Dibasic esters	4	0	0	0.2	1561	7270
Emulsion Remover						
Sodium periodate	0	0	0	0	47	218
Water	0	0	0	0	1210	5640
Ethoxylated nonylphenol	0	0	0	0	123	575
Other	0	0	0	0	181	844
Haze Remover						
N-methylpyrrolidone	6	0	0	0	780	3640
Dibasic esters	1	0	0	0	780	3639

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry

Table V-144
Occupational Risk Estimates for Alternative System Phi

Name	Hazard Quotient[b]			Margin Of Exposure[a]					
		Dermal		Inhalation		Dermal			
						Routine		Immersion	
	Inhalation	Routine	Immersion	NOAEL[c]	LOAEL[d]	NOAEL	LOAEL	NOAEL	LOAEL
Ink Remover									
Dibasic esters	NA	NA	NA	NA	NA	NA	NA	NA	NA
Emulsion Remover									
Sodium periodate	NA	NA	NA	NA	NA	NA	NA	NA	NA
Water	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ethoxylated nonylphenol	NA	NA	NA	NA	NA	NA	NA	NA	NA
Haze Remover									
N-methylpyrrolidone	NA	NA	NA	2076	NA	16	NA	3.3	NA
Dibasic esters	NA	NA	NA	NA	NA	NA	NA	NA	NA

[a]Margin of Exposure (MOE) values above 100 for a NOAEL and 1000 for a LOAEL indicate low risk.
[b]Hazard Quotient is the ratio of the estimated chronic dose/exposure level to the Reference Dose (RfD) or the Reference Concentration (RfC). Hazard Quotient values less than 1 imply that adverse effects are very unlikely to occur.
[c]NOAEL means No Observed Adverse Effect Level.
[d]LOAEL means Lowest Observed Adverse Effect Level.

Occupational Risk Conclusions and Observations

Ink Remover and Haze Remover

- Dermal exposures to N-methylpyrrolidone during haze removal present a concern for developmental toxicity risk based on the calculated margins-of-exposure. Similar estimates for inhalation exposures to N-methylpyrrolidone indicate very low concern.

- Risks from other ink remover and haze remover components could not be quantified because of limitations in hazard data, although dermal exposures to all components could be relatively high.

- Inhalation exposures to all other components are very low.

Emulsion Removers (All Systems)

- All of the systems that employ an emulsion remover use either a strong oxidizer such as hypochlorite or periodate or a strong base such as sodium hydroxide. The haze removers in Alpha, Epsilon, Gamma, Mu, Omicron, and Theta also contain these compounds. All of these materials present a high concern for skin and eye irritation and tissue damage if workers are exposed in the absence of proper protective clothing. None of the emulsion removers present significant inhalation risks.

Environmental Releases

Table V-145
Environmental Release Estimates in Screen Cleaning Operations
Method 2, Alternative System Phi

System	Release Under Each Scenario (g/day)						
	I			II	III	IV	
	air	water	land	air	air	air	water
Ink Remover							
Dibasic esters	8.1	0	766	0	0	0.3	1349
Emulsion Remover							
Sodium periodate	0	19	0	0	0	0	0
Water	0	481	0	0	0	0	0
Ethoxylated nonylphenol	0	49	0	0	0	0	0
Other	0	72	0	0	0	0	0
Haze Remover							
N-methylpyrrolidone	12	270	0	0.1	0	0	0
Dibasic esters	3.1	279	0	0	0	0	0

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry

Environmental Releases from Screen Reclamation Processes
Screen Reclamation Method 2, Alternative System Phi

From Ink Removal Operations:

Dibasic esters

8.4 g/day to air

1349 g/day to water from rags at commercial laundry

766 g/day to landfill

From Emulsion Remover:

Sodium periodate

19 g/day to water

Ethoxylated nonylphenol

49 g/day to water

Other

72 g/day to water

From Haze Remover:

N-methyl pyrrolidone

12.1 g/day to air
270 g/day to water

Dibasic esters

3.1 g/day to air
279 g/day to water

Table V-146
Summary of Estimated Daily Environmental Releases from a Hypothetical Facility Using Screen Reclamation Method 2, Alternative System Phi

Substance:	To Air:	To Water:	To Landfill:
Dibasic esters	11.5 g/day	279 g/day 1349 g/day at laundry	766 g/day
Sodium periodate		19 g/day	
Ethoxylated nonylphenol		49 g/day	
Other		72 g/day	
N-methyl pyrrolidone	12.1 g/day	270 g/day	

Releases to Water from a Single Facility

Table V-147
Estimated Releases to Water from Traditional Formulations from Screen Reclamation at a Single Facility Using Screen Reclamation Method 2, Alternative System Phi

Substance	Amount Released to Water from Facility	Waste water Treatment Removal Efficiency	Amount to Water After Waste water Treatment	Daily Stream Concentration, ug/L[a] for 1000 MLD Receiving Water
Dibasic esters	279 g/day 1349 g/day at laundry	84-97 %	13.8 g/day 66.4 g/day	1×10^{-2} 6×10^{-2}
Sodium periodate	19 g/day	100 %	0	0
Ethoxylated nonylphenol	49 g/day	100 %	0	0
Other	72 g/day	100 %	0	0
N-methyl pyrrolidone	270 g/day	97 %	8.1 g/day	8×10^{-3}

[a]ug/L is Micrograms per liter, which is parts per billion for a substance in water. MLD is Million liters per day.

Releases to Air from Individual Screen Printing Facilities

Table V-148
Air Release, Concentration and Potential Dose Estimates from a Single Model Facility Using Screen Reclamation Method 2, Alternative System Phi

Substance	Amount of Releases per day	Highest Average Concentration 100 M away	Annual Potential Dose, mg/year[a]
Dibasic esters	11.5 g/day	2.3×10^{-2} ug/m^3	2×10^{-1}
N-methyl pyrrolidone	12.1 g/day	2.5×10^{-2} ug/m^3	2×10^{-1}

[a]This estimates doses for people living 100 Meters from the hypothetical facility. The actual number of people who would fall into this range can be determined from census data, if the facility location is known. The model used to calculate concentrations is more completely explained in the Overview by Media-Air Section in Chapter III. To calculate the annual potential dose, the concentration is multiplied by the amount a person will breathe (20 m^3/day) and the number of days per year (365), and the units are converted to mg/year by dividing by 1000.

General Population Risk Conclusions and Observations

- Health risks to the general population from both air and water exposures are very low for Method 2, Product System Phi.

Although air releases were evaluated for only a single facility, it is very unlikely that an analysis of cumulative air releases would lead to different risk conclusions. Examples of general population exposure and risk estimates are shown for Method 2, Traditional System 1 in Methods 1 and 2 and Alternative System Chi in Method 2; please reference these sections as illustrative examples. Hazard Quotient values below one indicate very low risk. Margin-of-Exposure (MOE) values above 100 for a NOAEL or above 1000 for a LOAEL indicate very low risk.

Ecological Risks From Water Releases Of Screen Reclamation Chemicals

- None of the single facility releases of Method 2, Product System Phi reach an ecotoxicity concern concentration.

Performance

General Summary of Product System Phi, Performance, and Related Variables

This product system consisted of an ink remover, an emulsion remover, and a haze remover. It's performance was demonstrated at Facility 5 and Facility 23. Facility 5 employs approximately 15 people with 3 employees involved in the screen printing area of the business. They print interior signs, markings on parts, and identification badges. Facility 23 employs five people and prints mainly on plastics. Their products include front panels, overlays, and labels. Over a four week period, Facility 5 reclaimed 40 screens. Facility 23 used Product System Phi for two weeks and reclaimed 8 screens. During the demonstrations, both facilities primarily used solvent-based vinyl inks, but they also tried System Phi on acrylic vinyl, epoxy, and

metallic inks. Facility 5 used a capillary film emulsion on a polyester screen and Facility 23 used a dual-cure emulsion on a multifilament polyester screen.

Both facilities reported similar results with Product System Phi. At Facility 5, the ink remover broke down the ink effectively but required more effort than their own ink remover. Facility 23 found that the ink remover performance was inconsistent; it worked well on metallic inks, but did not remove ink from around the edges of the stencil when using vinyl ink. Both facilities noticed that the ink remover tended to deteriorate the stencil if it was not wiped off immediately after application. For this reason, the facilities felt that this product should not be used for in-process ink removal.

The emulsion remover was very effective and it easily removed the stencil with very little scrubbing. Both facilities reported the System Phi emulsion remover performed better than the product they were using before the demonstrations.

Facility 5 reported that a haze remained on the screen after using the haze remover, but it did not affect future print image quality. Over time, the printer felt this haze could potentially deteriorate the screen mesh. Facility 23 reported that the haze remover left a ghost image and some screens could not be reused for reverse printing or for printing with transparent inks.

Alternative System Phi Profile

The manufacturer recommends applying Product System Phi as follows:

- Ink Remover After carding off as much excess ink as possible, apply ink remover to the screen using a spray bottle. With a soft brush or sponge, work the ink remover into the screen. Rinse or wipe both sides of the screen with a lint-free cloth.

- Emulsion Remover Shake the bottle well and spray emulsion remover on both sides of the screens. Work the product into the screen using a nylon mesh pad or brush. If the product is too thick to spray, pour it from the spray bottle onto the brush or screen. Wait for 2 - 3 minutes, but do not allow the emulsion remover to dry. Rinse the screen with a pressure washer (a 1000 psi washer was used at SPTF).

- Haze Remover Allow the screen to dry before applying the haze remover. Place the screen flat side down on a non-porous surface. Spray the haze remover on the ghost image and/or emulsion residue to be removed. Using a nylon brush or pad, work the product into the screen. Wait for 2 - 3 minutes and rinse. For dried solvent inks, lacquers, enamels, vinyls, cured plastisol, or fixed emulsions, let sit for 30 minutes and wipe clean with lint free towel.

Alternative System Performance at SPTF

Product System Phi was tested at SPTF on two screens (one with a solvent-based ink, and one with a UV-curable ink). This product is not recommended for use on water-based inks. On both screens, the ink dissolved quickly with minimal effort. There was a slight blue color on the wipe (the color of the stencil), but upon inspection the stencil did not look like it was damaged or deteriorated. On the screen with solvent-based ink, six rags were needed to remove the ink, and on the UV ink screen, five rags were used. The technician noticed a slight odor.

The emulsion remover also worked well; it completely dissolved the stencil with only light scrubbing on both screens. After using the emulsion remover, the screen with solvent-based ink had a very light stain and slight ink residue in small areas. The haze remover lightened the stain only slightly, but it removed the ink residue. The screen with UV-curable ink had a dark ink stain and the haze remover lightened it somewhat, but did not remove it completely. The technician noted that the haze remover was very easy to use and required minimal effort. There was a slight odor to the product, but it was not unpleasant.

The recommended application procedure was followed with a few slight variations. The ink remover was allowed to sit on the screen for 30 seconds before it was rubbed in with a sponge. The haze remover was removed with a pressure wash.

Alternative System Performance Details

Performance Details from Facility 5

At the conclusion of the Performance Demonstrations, the printer was asked to compare the performance of each component of Product System Phi to the system they previously used at this facility. Overall, the printer felt the emulsion remover worked better, and the ink remover and the haze remover did not work as well as their previous reclamation products.

On most screens the printer reported that the ink was removed effectively, however, there was an light to moderate ink haze remaining on 35% of the screens after using the ink remover. This facility found the ink remover performance was the same whether used on vinyl inks or on epoxies. Although not included in the Performance Demonstration protocol, the printer used this product as an in-process ink remover, not just as a reclamation ink remover. He found it would start to deteriorate the stencil if left on the screen for more than a few seconds. By spraying on the ink remover, wiping it off very quickly, and allowing the screen to dry before printing, he was able to use it in-process without affecting the print quality.

The printer was very enthusiastic about the emulsion remover, commenting that it consistently dissolved the stencil very quickly with minimal effort. After the conclusion of the Performance Demonstrations, he requested more information on the product so he could continue to use it in his facility.

The haze remover performance was not up to the standards of this printing facility. When following the manufacturer's application instructions, the haze remover did not remove the haze satisfactorily. The printer commented that he thought the haze remaining on the screen would deteriorate the screen over time. To improve the performance, the printer let the haze remover sit on the screen overnight (instead of the recommended 3 - 5 minutes), he wiped the product off with rags before pressure washing, and he tried using more ink remover hoping that there would be less ink stain later. None of these techniques improved the performance of the product. The printer did note that he preferred the very mild odor of this product to the strong, unpleasant odor of his own haze remover.

In reviewing the data from the printer's evaluation forms, there does not seem to be a correlation between any specific screen condition (e.g., ink type, ink color, number of impressions) and variations in the product performance. Overall, the use of Product System Phi had no deleterious effects on the screen mesh or on the subsequent print quality image and the printer did not notice any change in screen failure rate over the time period that the alternative system was in use.

Performance Details from Facility 23

Generally, this facility felt the emulsion remover worked well, but they were not satisfied with the ink remover and the haze remover of Product System Phi. While the actual performance of the alternative system was often adequate, the procedures involved with using the products disrupted the facility's routine. After two weeks of demonstrations, this facility discontinued their participation in the project and only submitted data on 8 screens. In addition to problems with the product application procedures, this facility experienced personnel problems that contributed to their decision to discontinue their participation after two weeks. The main screen printer/screen reclaimer involved with the demonstrations was absent for two weeks in the middle of the project. No screen reclamation with the alternative system continued during her absence. When she returned, so much work had accumulated that the facility decided they could not spare the time for the demonstrations.

The printer found the performance of the ink remover to be inconsistent. When using metallic inks, the alternative ink remover worked better than their standard product. With other ink types, the ink remover did not effectively remove the ink from the edges of the stencil and it did not remove as much ink from the screen as their standard product. Their standard ink remover is a solvent blend whose chemical composition is very different from that of the alternative ink remover. On older screens that have been reclaimed many times, adverse chemical interactions between the standard products and the alternative system could occur due to these differences.

The printer felt the emulsion remover was as effective as their standard product, and it dissolved the stencil faster than their standard emulsion remover.

Product System Phi haze remover required more contact time with the screen than this facility's usual haze remover. This additional waiting time impeded the facility's ability to reuse screens at the needed rate. In addition to the inconvenient wait time, the haze remover often did not reduce the haze sufficiently and the facility had to follow up with their usual product before the screen could be reused. The printer noted that the haze remover was less irritating to the respiratory system than their usual haze remover.

During the two weeks the products were used in this facility there was no noticeable mesh deterioration, no change in the screen failure rate, and no change in print quality.

Alternative System Performance Table Compiled from Field Sites

The table below highlights the observed performance of the product system and the relevant conditions of the demonstration, as recorded by the printers using the products at the demonstration facilities. In addition to the field demonstration performance data, results of the product tests performed at SPTF are also summarized in this table. More descriptive information on the demonstration facilities is included in the section following the table.

Facility Profiles

General Facility Background for Facility 5

Facility 5 makes interior signs, marks parts, and prints identification badges. Primarily, they print on plastics and on metals. A typical run is 100 pieces, and approximately 80% of their orders are repeat orders. Of the 15 employees at this facility, approximately 3 are

Table V-149
On-Site Performance Summary For Alternative System Phi

		Performance						Demonstration Conditions			
	System Component	Avg Drying Time Before Using Product	Average Quantity Applied	Average Cleaning Time	Average Effort Required	Performance for Each System Component	Overall System Performance	Inktype(s)	Emulsion type	Mesh type; Thread count	Average Screen Size
In-field Demonstrations at Volunteer Printing Facilities											
Facility 5	*Ink remover*	2.5 ± 9.6 mins (n=40)	1.3 ± 0.5 oz. (n=40)	3.7 ± 4.2 mins (n=40)	Moderate	Light/Moderate ink haze on 35% of screens.	• Ink remover deteriorated the stencil. • Light ink stain remained after reclamation.	Solvent-based (primarily vinyl, some epoxy)	Capillary film	Polyester, no treatment; 305 threads/inch	2815 in^2
	Emulsion Remover	1.3 ± 0.6 mins (n=40)	1.7 ± 0.5 oz. (n=40)	2.6 ± 0.5 mins (n=40)	Moderate	Quickly, easily removed stencil.					
	Haze Remover	8.2 ± 37.6mins (n=40)	1.1 ± 0.5 oz. (n=40)	1.6 ± 0.5 mins (n=40)	Moderate	Did not consistently remove haze.					
Facility 23	*Ink Remover*	50.6 ± 40.6 hrs (n=9)	2.0 ± 1.9 oz. (n=9)	6.9 ± 10.6 mins (n=9)	Low	Inconsistent performance. Worked well on metallic inks; did not work well on other inks used.	• Facility stopped using the product after 2 weeks because of the additional time required for the haze remover and personnel problems. • Ink remover deteriorated the stencil and could not be used in process.	Solvent-based vinyl	Dual-cure	Multi-filament polyester; 195 - 305 threads/inch	883 in^2
	Emulsion Remover	48.0 ± 40.8 hrs (n=10)	1.0 ± 0.0 oz. (n=10)	2.9 ± 1.4 mins (n=10)	Low/ Moderate	Quickly, easily removed stencil.					
	Haze Remover	1.6 ± 0.8 mins (n=10)	1.2 ± 0.4 oz. (n=10)	12.2 ± 14.1 mins (n=10)	Moderate	30 min. wait time required caused scheduling problems at this facility.					

Table V-150
Laboratory Performance Summary For Alternative System Phi

	System Component	Performance						Demonstration Conditions			
		Avg Drying Time Before Using Product	Average Quantity Applied	Average Cleaning Time	Average Effort Required	Performance for Each System Component	Overall System Performance	Ink type(s)	Emulsion type	Mesh type; Thread count	Average Screen Size
Laboratory Testing at SPTF											
SPTF Solvent-based Ink	*Ink Remover*	15 mins	2.5 oz.	6.7 mins	Low	Ink dissolved easily.		Solvent-based	Dual cure direct	Polyester; 255 threads/inch	360 in^2
	Emulsion Remover	24 hours	0.5 oz.	6.4 mins	Low	Stencil dissolved easily; slight ink residue and light stain remaining.					
	Haze Remover	0 mins	1.0 oz.	5.6 mins	Low	Lightened stain slightly; removed residue.					
SPTF UV-curable Ink	*Ink Remover*	15 mins	2.0 oz.	5.5 mins	Low	Ink dissolved very easily.		UV-curable	Dual cure direct	Polyester; 390 threads/inch	360 in^2
	Emulsion Remover	24 hours	0.5 oz.	5.5 mins	Low	Stencil dissolved easily; dark ink stain remaining.					
	Haze Remover	0 mins	0.5 oz.	6.2 mins	Low	Lightened ink stain, but did not remove it.					

involved in screen printing operations and 1 employee is responsible for screen reclamation activities. The facility uses a variety of solvent-based inks including vinyl-based inks, epoxy inks and a multipurpose ink. They use capillary film for their emulsion. All screens used in the Performance Demonstrations were polyester (no treatment) with a typical mesh count of 305 threads/inch. The average screen size at this facility is 20" x 20" and approximately 2 - 3 screens are reclaimed daily.

Screen Reclamation Area in Facility 5

The screen printing, ink removal, and screen reclamation activities are all done in the same room which is approximately 100 ft^2 in size. A fan and the door to outside provide ventilation for the room. The average temperature during the observer's visit was 68°F (and 40% relative humidity), but when an oven located in the same room is in operation, the temperature can increase significantly. Rags used for ink removal are disposed of as non-hazardous waste. Waste water from the high pressure wash of the emulsion remover and haze remover is not recycled or filtered at this facility.

Current Screen Reclamation Products at Facility 5

The standard ink remover used at Facility 5 is a blend which contains 55% - 56% propylene glycol ether. For emulsion removal, they use a product which contains sodium metaperiodate (5%) and their standard haze remover contains sodium hydroxide (<15%).

Current Screen Reclamation Practices in Facility 5

This facility primarily uses a multipurpose ink remover, however, when using specialized inks (20% of their jobs), they use the ink remover recommended by the ink manufacturer. Emulsion remover and haze remover are used on all screens. For their standard inks, the screen reclamation process is described below:

- Ink Remover: Immediately after the printing job is completed, card off excess ink from the screen with cardboard. Apply ink remover to a reusable rag from a safety can. Gloves are usually worn during this step. Wipe both sides of the screen with the rag. Continue wiping with clean rags until ink no longer comes off on the rag. Typically, 2 - 4 rags are used on each screen. Wipe both sides of the screen with a dry rag to remove oily film.

- Emulsion Remover: Screen reclamation is usually done at the end of the work day for several reasons: screens that are used throughout the day can all be reclaimed at the same time for more efficient operation, the haze remover can dry overnight, and fewer employees are subject to the strong, unpleasant odor of the haze remover. To apply the emulsion remover, dip a brush into the product container, wearing gloves, and brush the emulsion remover into both sides of the screen. Wait for 1 - 5 minutes. Rinse both sides of the screen with a high pressure (1000 psi) wash. Wipe both sides of the screen with a dry rag.

- Haze Remover: Typically, haze remover is used immediately after emulsion removal, at the end of the day. The haze remover is a two-part system. To apply, dip a nylon brush into the pail containing the first haze remover component, wearing gloves, eye protection, and a respirator (if desired). Rub the haze remover into the dry screen on both sides. Allow to dry overnight. Rinse with a high

pressure wash. Apply the second part of the haze remover product with a brush. Wait for one minute. Rinse with a high pressure wash.

General Facility Background for Facility 23

The majority of the products printed by Facility 23 are front panels, overlays, and labels on plastics. They also do some printing on paper, metals, and glass. Run lengths are typically 150 impressions, and approximately 82% of their business is for repeat orders. There are less than 5 employees at this facility and two are involved in screen reclamation operations. The facility uses several types of solvent-based inks including vinyls, acrylic vinyls, and epoxy inks. They use a dual-cure emulsion and a multifilament (untreated) polyester mesh. Mesh counts used in the Performance Demonstrations ranged from 195 - 305 threads/inch. The average screen size at this facility is 1,305 in^2 and approximately 3 - 5 screens are reclaimed daily.

Screen Reclamation Area in Facility 23

Ink removal is done at press side and screen reclamation takes place nearby in a back-lit spray booth. The facility-wide ventilation covers both work areas. During the observer's visit, the average temperature in the ink removal area was 70°F (and 35% relative humidity), and the screen reclamation area temperature was 62°F (and 55% relative humidity). Rags used for ink removal are cleaned under a contract with an industrial laundry service. Spent solvent from ink removal operations and ink waste are disposed of as hazardous waste. Waste water from the washes of the emulsion remover and haze remover is not recycled or filtered at this facility.

Current Screen Reclamation Products at Facility 23

For ink removal, Facility 23 uses a proprietary blend which contains at least xylene, propylene glycol methyl ether, and diacetone alcohol. Their standard emulsion remover product is 100% sodium periodate, and their standard haze remover is a proprietary aqueous mixture which contains sodium hydroxide (<15%).

Current Screen Reclamation Practices in Facility 23

At Facility 23, the application procedure described below is used for most screens. Usually, four screens are reclaimed at the same time. The reclamation procedure is as follows:

- Ink Remover: At the press, scrape the excess ink off the screen. Wearing gloves, wipe the edges of the screen with disposable lint-free wipes. Dampen a reusable rag with ink remover from a pump can and wipe both sides of the screen. Continue dampening the rag and wiping until the ink is no longer coming off on the rag. Usually, one or two rags are used on each screen. Once the rag stops picking up the ink, use a blow dryer to evaporate the solvent from the screen.

- Emulsion Remover: Put the screen in the sink and wet the screen. Wearing gloves and eye protection, spray emulsion remover onto both sides of the screen and let it sit for approximately two minutes. Rinse with a high pressure (1000 psi) water spray.

- Haze Remover: Dip a brush into the bucket of haze remover, wearing gloves, eye protection, and, if desired, an apron and respirator. Rub the haze remover into the screen on the effected area on both sides. Wait for 3 - 5 minutes for screens on retensionable frames and 5 - 10 minutes for screens on fixed frames. Rinse with a low pressure water spray, followed by a high pressure wash.

Cost

Table V-151
Method 2: Summary of Cost Analysis for Alternative System Phi

Cost Element Description		Baseline (Traditional System 4)	Alternative System Phi	
			Facility 5	Facility 23
Facility Characteristics				
Average screen size (in^2)		2,127	2,815	883
Average # screens/day		6	3	4
Cost Elements per Screen				
Labor	Time spent applying, scrubbing, and removing reclamation products (min)	24.4	8.0	22.0
	Cost ($)	5.33	1.74	4.81
Materials and Equipment	# of rags used	3	2.9	1.3
	Cost ($)	0.45	0.43	0.19
Reclamation Product Use	Ink Remover Average Volume (oz.)	8.0	1.3	2.0
	Cost ($)	0.22	0.25	0.39
	Emulsion Remover Average Volume (oz.)	3.5	1.7	1.0
	Cost ($)	0.13	0.33	0.19
	Haze Remover Average Volume (oz.)	3.0	1.1	1.2
	Cost ($)	0.12	0.35	0.37
Hazardous Waste Disposal	Amount (g)	34	0	0
	Cost ($)	0.02	0	0
Totals				
Total Cost ($/screen)		6.27	3.11	5.96
Normalized[a]		6.27	6.10	7.82
Total Cost ($/year)		9,399	1,991	5,957
Normalized[a]		9,399	9,233	11,728

[a]Normalized values adjust product usage, number of screens cleaned, and number of rags laundered at demonstration facilities to reflect the screen size and number of screens cleaned per day under the baseline scenario. Labor costs, however, are not normalized. Normalization allows a comparison between the baseline and facility results.

Note: For additional information regarding product performance see performance demonstration summaries.

Product System Omicron-AE

Formulation

Ink Remover	Diethylene glycol butyl ether
	Propylene glycol
Emulsion Remover	Sodium periodate
	Ethoxylated nonylphenol
	Water
Haze Remover	Ethoxylated nonylphenol
	Phosphate surfactant
	Water
	Other

Occupational Exposure

Table V-152
Occupational Exposure Estimates for Alternative System Omicron-AE

System	Inhalation (mg/day)				Dermal (mg/day)	
	I	II	III	IV	Routine	Immersion
Ink Remover						
Diethylene glycol butyl ether	0	0	0	0	984	4590
Propylene glycol	17	0.1	0	0.4	576	2690
Emulsion Remover						
Sodium Periodate	0	0	0	0	47	218
Ethoxylated nonylphenol	0	0	0	0	31	146
Water	0	0	0	0	1480	6920
Haze Remover						
Other	0	0	0	0	109	510
Ethoxylated nonphenol	0	0	0	0	16	73
Phosphate surfactant	0	0	0	0	78	364
Water	0	0	0	0	1360	6330

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry

Table V-153
Occupational Risk Estimates for Alternative System Omicron AE

Name	Hazard Quotient[b]			Margin Of Exposure[a]					
				Inhalation		Dermal			
		Dermal				Routine		Immersion	
	Inhalation	Routine	Immersion	NOAEL[c]	LOAEL[d]	NOAEL	LOAEL	NOAEL	LOAEL
Ink Remover									
Diethylene glycol butyl ether	NA	NA	NA	NA	NA	142	3.6	30	0.8
Propylene glycol	0.01	0.4	1.9	NA	NA	NA	NA	NA	NA
Emulsion Remover	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium periodate	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ethoxylated nonylphenol	NA	NA	NA	NA	NA	NA	NA	NA	NA
Water	NA	NA	NA	NA	NA	NA	NA	NA	NA
Haze Remover									
Ethoxylated nonylphenol	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phosphate surfactant	NA	NA	NA	NA	NA	NA	NA	NA	NA
Water	NA	NA	NA	NA	NA	NA	NA	NA	NA

[a]Margin of Exposure (MOE) values above 100 for a NOAEL and 1000 for a LOAEL indicate low risk.
[b]Hazard Quotient is the ratio of the estimated chronic dose/exposure level to the Reference Dose (RfD) or the Reference Concentration (RfC). Hazard Quotient values less than 1 imply that adverse effects are very unlikely to occur.
[c]NOAEL means No Observed Adverse Effect Level.
[d]LOAEL means Lowest Observed Adverse Effect Level.

Occupational Risk Conclusions and Observations

Ink Remover and Haze Remover

- Margin-of-exposure calculations indicate clear concerns for chronic dermal exposures to workers using diethylene glycol butyl ether in ink removal.

- Margin-of-exposure calculations also show possible concerns for developmental toxicity risks from dermal "immersion" exposures to diethylene glycol butyl ether. Routine dermal exposures, however, represent a very low concern for developmental toxicity risks.

- Hazard quotient calculations for inhalation and dermal exposures to propylene glycol during ink removal indicate very low concern.

- Inhalation exposures to other components are very low.

- Risks from other components could not be quantified because of limitations in hazard data, although dermal exposures to all components could be relatively high.

Emulsion Removers (All Systems)

- All of the systems that employ an emulsion remover use either a strong oxidizer such as hypochlorite or periodate or a strong base such as sodium hydroxide. The haze removers in Alpha, Epsilon, Gamma, Mu, Omicron, and Theta also contain these compounds. All of these materials present a high concern for skin and eye irritation and tissue damage if workers are exposed in the absence of proper protective clothing. None of the emulsion removers present significant inhalation risks.

Environmental Releases

Table V-154
Environmental Release Estimates in Screen Cleaning Operations
Method 2, Alternative System Omicron-AE

System	Release Under Each Scenario (g/day)						
	I			II	III	IV	
	air	water	land	air	air	air	water
Ink Remover							
Diethylene glycol butyl ether	0	0	440	0	0	0	852
Propylene glycol	35	0	222	0.2	0.1	0.7	497
Emulsion Remover							
Sodium periodate	0	19	0	0	0	0	0
Ethoxylated nonylphenol	0	13	0	0	0	0	0
Water	0	603	0	0	0	0	0
Haze Remover							
Other	0	43	0	0	0	0	0
Ethoxylated nonphenol	0	6.2	0	0	0	0	0
Phosphate surfactant	0	31	0	0	0	0	0
Water	0	540	0	0	0	0	0

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry

Environmental Release Estimates from Screen Reclamation Processes
Screen Reclamation Method 2, Alternative System Omicron-AE

From Ink Removal Operations:

Diethylene glycol butyl ether

852 g/day to water from rags at commercial laundry

440 g/day to landfill

Propylene glycol

36 g/day to air

497 g/day to water from rags at commercial laundry

222 g/day to landfill

From Emulsion Remover:
Sodium periodate
19 g/day to water
Ethoxylated nonylphenol
13 g/day to water

From Haze Remover:
Other
43 g/day to water
Ethoxylated nonylphenol
6.2 g/day to water
Phosphate surfactant
31 g/day to water

Table V-155
Summary of Estimated Daily Environmental Releases from a Hypothetical Facility Using Screen Reclamation Method 2, Alternative System Omicron-AE

Substance:	To Air:	To Water:	To Landfill:
Diethylene glycol butyl ether		852 g/day at laundry	440 g/day
Propylene glycol	36 g/day	497 g/day at laundry	222 g/day
Sodium periodate		19 g/day	
Ethoxylated nonylphenol		19.2 g/day	
Other		43 g/day	
Phosphate surfactant		31 g/day	

Releases to Water from a Single Facility

Table V-156
Estimated Releases to Water from Traditional Formulations from Screen Reclamation at a Single Facility Using Screen Reclamation Method 2, Alternative System Omicron-AE

Substance	Amount Released to Water from Facility	Waste water Treatment Removal Efficiency	Amount to Water After Waste water Treatment	Daily Stream Concentration, ug/L[a] for 1000 MLD Receiving Water
Diethylene glycol butyl ether	852 g/day at laundry	83 %	145 g/day	1×10^{-1}
Propylene glycol	497 g/day at laundry	97 %	14.9 g/day	1×10^{-2}
Sodium periodate	19 g/day	100 %	0	0
Ethoxylated nonylphenol	19.2 g/day	100 %	0	0
Other	43 g/day	100 %	0	0
Phosphate surfactant	31 g/day	100 %	0	0

[a] ug/L is Micrograms per liter, which is parts per billion for a substance in water. MLD is Million liters per day.

Releases to Air from Individual Screen Printing Facilities

Table V-157
Air Release, Concentration and Potential Dose Estimates from a Single Model Facility Using Screen Reclamation Method 2, Alternative System Omicron-AE

Substance	Amount of Releases per day	Highest Average Concentration 100 M away	Annual Potential Dose, mg/year[a]
Propylene glycol	36 g/day	7.3×10^{-2} ug/m^3	5×10^{-1}

[a]This estimates doses for people living 100 Meters from the hypothetical facility. The actual number of people who would fall into this range can be determined from census data, if the facility location is known. The model used to calculate concentrations is more completely explained in the Overview by Media-Air Section in Chapter III. To calculate the annual potential dose, the concentration is multiplied by the amount a person will breathe (20 m^3/day) and the number of days per year (365), and the units are converted to mg/year by dividing by 1000.

General Population Risk Conclusions and Observations

- Health risks to the general population from both air and water exposures are very low for Method 2, Product System Omicron-AE.

Although air releases were evaluated for only a single facility, it is very unlikely that an analysis of cumulative air releases would lead to different risk conclusions. Examples of general population exposure and risk estimates are shown for Method 2, Traditional System 1 in Methods 1 and 2 and Alternative System Chi in Method 2; please reference these sections as illustrative examples. Hazard Quotient values below one indicate very low risk. Margin-of-Exposure (MOE) values above 100 for a NOAEL or above 1000 for a LOAEL indicate very low risk.

Ecological Risks From Water Releases Of Screen Reclamation Chemicals

- None of the single facility releases of Method 2, Product System Omicron-AE reach an ecotoxicity concern concentration.

Performance

General Summary of System Omicron-AE Performance, and Related Variables

Product System Omicron-AE and Product System Omicron-AF were submitted for demonstration by the same manufacturer. They have the same ink remover and the same emulsion remover, but each one has a different haze remover to complete the system. Although these systems do share a common ink remover and emulsion remover, Omicron-AE and Omicron-AF are each evaluated as a separate Product System in this documentation. It was the intention of the Performance Demonstrations to evaluate reclamation systems as a whole, not individual products, whenever possible.

The performance of Omicron-AE was demonstrated at Facilities 2 and 19. This product system consisted of an ink remover, an emulsion remover, and a haze remover. A degreaser also accompanied this product system and was used by one of the facilities, however, detailed information on the performance of the degreaser is not included in the scope of this project. Facility 2 prints signs, and displays; Facility 19 prints overlays, and membrane switches. During the demonstration, Facility 2 reclaimed 30 screens using solvent-based inks over a 4 week period. Facility 19 did not participate in the demonstrations after the observer's one day visit. During the visit, they reclaimed four screens, but based on the poor results of those first reclamations, they decided not to participate in the project. Neither facility tried alternative application techniques to improve product performance.

Facility 2 reported that the ink remover performed poorly and required a lot more scrubbing than their usual product. The chemical composition of the alternative ink remover was extremely different than the constituents of the facility's standard product. Adverse interactions may have occurred because of these chemical differences. The ink remover seemed to work better when used immediately after printing, but the performance was still not acceptable. At Facility 19, the ink remover had to be re-applied and scrubbed into the screen repeatedly, and all residual ink was still not removed.

In general, Facility 2 liked the emulsion remover better than their usual product, although it took extra time to use the hand sprayer and the emulsion remover was not as effective when thick ink residue was present. Facility 19 was not satisfied with the emulsion remover performance. They reported that the emulsion remover had to be re-applied and scrubbed into the screen repeatedly; even then residual emulsion was left on the screen.

Both facilities found the haze remover performance to be unacceptable. Facility 2 saw no reduction in haze after applying the product. At Facility 19, the haze remover did not completely remove the haze. This facility, however, had very high standards in terms of haze removal; other facilities would have been satisfied with this level of haze removal. It should be noted that both facilities used standard haze removers that were very different chemically than the alternative haze remover. On screens that were reclaimed many times, there is potential for adverse effects due to interaction of the standard and alternative systems.

Alternative System Omicron-AE Profile

The manufacturer recommends applying Product System Omicron-AE as follows:

- Ink Remover Card off the extra ink left in the screen. Apply the ink remover with a spray bottle to both sides of the screen. Brush the product into the screen to loosen the ink on both sides. Wipe the screen clean. Repeat spraying and wiping until the screen is clean.

- Emulsion Remover Place the screen in a washout sink and spray both sides of the stencil with the emulsion remover so that it evenly covers the stencil. Wait one minute. Use a soft brush to loosen the stencil and scrub the screen until the stencil is broken up in all areas. Apply more emulsion remover if necessary. Rinse the screen with a pressure washer (a 1000 psi pressure wash was used at SPTF).

- Haze Remover Spray the haze remover on the stained areas on both sides of the screen. Brush the product in and let stand for 3 - 4 minutes. Pressure rinse from the bottom of the screen to the top on both sides.

Alternative System Performance at SPTF

Product System Omicron-AE was tested at SPTF on three screens (one with a solvent-based ink, one with a UV-curable ink, and one with a water-based ink). Products were applied according to the manufacturer's recommended application procedure. On the screens with the solvent-based ink and with UV ink, the ink dissolved well with little effort. On the solvent-based ink screen, the stencil was affected in the half-tone area, but there was no effect on the stencil on the UV ink screen. Six wipes were used to remove the ink from each screen. On the screen with water-based ink, the ink dissolved well, however, extra scrubbing was needed. The stencil was affected in the half-tone area. Again, six wipes were used.

On all three screens, the emulsion remover dissolved the stencil effectively. On the screen with solvent-based ink and the UV ink screen, moderate scrubbing was required to break up the stencil and the pressure wash remove the stencil completely. A light to moderate ink stain remained on each screen. On the screen with water-based ink, the stencil dissolved easily with only light scrubbing, but there was a small amount of ink residue remaining in the half-tone areas, in addition to a moderate ink stain.

The haze remover lightened the stains on all three screens and removed the ink residue on the water-based ink screen. However, all screens did have some ink stain remaining after the application of the haze remover.

Alternative System Performance Details

Performance Details from Facility 2

Except for the emulsion remover, Product System Omicron-AE performed poorly at this facility. Unfortunately, this facility became very busy during the demonstration period. The excessive workload reduced the amount of time available for using the alternative system and for experimenting with the application procedures. A total of 30 screens were reclaimed with Product System Omicron-AE over a 4 week period, but the Omicron-AE ink remover and haze remover were only used on 7 of the screens, due to poor performance. The Omicron-AE emulsion remover was used on 26 screens and worked very well.

The ink remover did not work well at this facility, which used solvent-based ink during the demonstrations. The screen reclaimer scrubbed one screen for 40 minutes trying to get the ink out of the mesh, whereas no scrubbing is needed with their usual ink remover. The alternative ink remover was chemically very different than this facility's standard product and chemical interactions could have occurred. Their usual ink removing method involved spraying solvent onto a screen in a small, closed room. This was a particularly unpleasant room in that there was a high concentration of solvents in the air, and there was also a lot of build-up of ink solids on the floor and walls. No respirators were seen when the observer was on-site, although the facility reported that respirators are usually worn in the "solvent room." Use of the alternative ink remover did not require the reclaimer to be in the ink reclamation room.

Facility 2 liked the performance of the emulsion remover very much and they thought it performed better than their usual product, even when diluted at one part emulsion remover to two parts water. The manufacturers application procedure did not instruct the printer to dilute the emulsion remover. When there was a thick ink residue left in the screen, the emulsion was more difficult to remove.

The haze remover did not reduce the haze in the screen mesh at all. The standard haze remover at this facility contains some very strong chemicals such as dichloromethane and has a very different chemical composition from the alternative haze remover. These differences could result in adverse chemical interactions on the screen. to improve performance, this facility used the alternative haze remover concurrently with Comet cleanser to remove the haze. Comet is typically used at this facility as a degreaser.

No changes in screen failure rate were noted during the demonstrations, but it could be speculated that a reduced screen failure rate would result from longer term use of the alternative system at this facility because of the abrasiveness of their usual products (such as Comet). Unfortunately, the lower abrasiveness of the alternative system may be offset by the amount of scrubbing required to get the screens clean. The reclaimer noted that his scrubbing was producing visible wear in the screen mesh.

Performance Details from Facility 19

This facility did not continue using System Omicron-AE after the initial demonstration during the observer's visit. The alternative system did not clean the screens to a level at all acceptable to this facility and they were not willing to experiment with different application procedures that may have improved performance. Also, the alternative system seemed to require more time and effort than the facility's usual procedures.

This facility has one screen reclaimer per shift and neither speak English. Forms were going to be translated into Spanish and the printing manager was present for much of the demonstrations and served as an interpreter. This facility tends to wash about 24 screens at a time in groups of eight. Using the alternative system severely interrupted the reclamation process established at this facility. This facility reclaims about 60 to 80 screens per shift. Currently, they only use one product for ink removal, emulsion removal, and haze removal. It is a very effective product, but the observer noticed it is also corrosive and emits strong vapors. Other facilities that use this product try to limit its use. This facility uses no other reclamation products and expects all screens to be completely without haze when reclamation is finished. Other facilities have less stringent haze removal requirements or expectations. The alternative system performance would probably have been considered acceptable at many other facilities. Also note that there may have been adverse chemical interactions between this facility's standard haze remover and the alternative haze remover, because the two haze removers are chemically very different.

During the observer's visit, the alternative system was used with different ink systems and several application techniques were evaluated. The type of ink did not seem to affect the alternative system performance levels. No changes in the rate of screen wear or failure were noted during the product demonstration. It is likely that the alternative system would be less corrosive than their standard product in the long term.

The ink remover did not work effectively enough for this facility. Average ink removal was observed, but the ink remover often had to be applied and scrubbed into the screen multiple times. Ink often remained in the screen at the edges of the print image and stencil. This level of removal did not compare to the results this facility has using their standard product as an ink remover, where usually no scrubbing is needed.

The emulsion remover often did not remove all of the emulsion from the screen. The emulsion remover required more scrubbing than with their standard product. Often, multiple applications were required to remove all of the emulsion. Still, emulsion tended to remain in the screen around the edges of the stencil.

The haze remover worked fairly well leaving only a light haze. This haze, which would have been acceptable at many of the other facilities participating in the project, was unacceptable for this facility. Even when the haze remover was allowed to stay on the screen for longer than the directions suggested, no appreciable improvement in performance was noted. When Facility 19 uses their usual haze remover, the haze disappears from the screen.

Alternative System Performance Table Compiled from Field Sites

The following table highlights the observed performance of the product system and the relevant conditions of the demonstration, as recorded by the printers using the products at the demonstration facilities. In addition to the field demonstration performance data, results of the product tests performed at SPTF are also summarized in this table. More descriptive information on the demonstration facilities is included in the section following the table.

Facility Profiles

General Facility Background for Facility 2

Facility 2 prints signs, banners, and store displays on plastics and paper. A typical run is 150 pieces and approximately 40% of their orders are repeat orders. Of the approximately

Table V-158
On-Site Performance Summary For Alternative System Omicron AE

	System Component	Performance						Demonstration Conditions			
		Avg Drying Time Before Using Product	Average Quantity Applied	Average Cleaning Time	Average Effort Required	Performance for Each System Component	Overall System Performance	Ink type(s)	Emulsion type	Mesh type; Thread count	Average Screen Size
In-field Demonstrations at Volunteer Printing Facilities											
Facility 2	*Ink remover*	7.1 ± 9.3 hrs (n=14)	12.6 ± 13.1 oz. (n=7)	18.6 ± 15.5 mins (n=7)	Moderate	Ink residue not removed from mesh.	• Only 7 screens reclamined w/system, due to poor performance.	Solvent-based inks	Direct photo stencil	Mesh type not specified; 230 threads/in.	5663 in^2
	Emulsion remover	1.3 ± 3.7 hrs (n=30)	7.5 ± 3.7 oz. (n=26)	6.6 ± 3.4 mins (n=26)	Low	Easily, completely removed stencil.					
	Haze remover	2.2 ± 6.7 hrs (n=30)	14.6 ± 5.1 oz. (n=7)	15.0 ± 4.1 mins (n=7)	Low	Seemed to have no effect on the haze.					
Facility 19	*Ink remover*	3.7 ± 1.5 hrs (n=3)	2.3 ± 1.2 oz. (n=3)	7.3 ± 4.5 mins (n=3)	High	Ink remained in screen after several applications.	• Did not participate after observer's visit, due to poor product performance.	Solvent-based	Direct photo stencil	PeKap; 156 - 390 threads/in.	957 in^2
	Emulsion Remover	not recorded (n=0)	1.3 ± 0.6 oz. (n=3)	3.3 ± 0.6 mins (n=3)	Moderate	Reapplication needed to remove emulsion.					
	Haze Remover	3.0 mins (n=1)	2.3 ± 2.5 oz. (n=4)	10.0 ± 9.3 mins (n=4)	High/ Moderate	Lightened the ink stain.					

Table V-159
Laboratory Performance Summary For Alternative System Omicron AE

		Performance						Demonstration Conditions			
	System Component	Avg Drying Time Before Using Product	Average Quantity Applied	Average Cleaning Time	Average Effort Required	Performance for Each System Component	Overall System Performance	Ink type(s)	Emulsion type	Mesh type; Thread count	Average Screen Size
Laboratory Testing at SPTF											
SPTF Solvent-based Ink	*Ink Remover*	15 mins	3.0 oz.	8.3 mins	Low	Dissolved ink well. Stencil affected in areas.		Solvent-based	Dual cure direct	Polyester; 260 threads/ inch	360 in^2
	Emulsion Remover	24 hours	0.5 oz.	3.8 mins	Moderate	Dissolved stencil. Light ink stain remaining.					
	Haze Remover	0 mins	0.5 oz.	5.0 mins	Low	Lightened, but did not remove, ink stain.					
SPTF UV-curable Ink	*Ink Remover*	15 mins	2.0 oz.	7.3 mins	Low	Dissolved ink well.		UV-curable	Dual cure direct	Polyester; 390 threads/ inch	360 in^2
	Emulsion Remover	24 hours	0.5 oz.	4.2 mins	Moderate	Dissolved stencil. Medium ink stain remaining.					
	Haze Remover	0 mins	0.5 oz.	5.1 mins	Low	Lightened, but did not remove, ink stain.					
SPTF Water-based Ink	*Ink Remover*	15 mins	3.0 oz.	7.2 mins	Moderate	Dissolved ink with wiping. Stencil affected in areas.		Water-based	Dual cure direct	Polyester; 260 threads/ inch	360 in^2
	Emulsion Remover	24 hours	1.0 oz.	3.5 mins	Low	Dissolved stencil. Medium ink stain and residue.					
	Haze Remover	0 mins	1.0 oz.	5.5 mins	Low	Lightened, but did not remove, ink stain.					

12 employees at this facility, 5 are involved in screen reclamation. All printing is done with solvent-based inks and the screens used in the Performance Demonstrations all had a mesh count of 230 threads/inch with a direct photo stencil. The typical screen size at this facility is 50 ft^2 and about 6 screens are reclaimed daily.

Screen Reclamation Area in Facility 2

Ink removal is done in a spray booth in the "solvent room" which is approximately 30 ft^2 in size and is not ventilated. Screen reclamation is done in a spray booth in the general plant area and is ventilated by the facility-wide system. The average temperature during the observer's visit was 65°F (and 49% relative humidity). Ink remover solvent is filtered, recycled and reused in-house. Waste water from the emulsion and haze remover booth is not recycled or filtered.

Current Screen Reclamation Products at Facility 2

Facility 2 uses a proprietary ink remover that includes at least toluene (31%), xylene (24%), methyl isobutyl ketone (19%), ethylbenzene (6%) and diacetone alcohol. Their standard emulsion remover contains at least sodium periodate. For haze removal, they use a proprietary solvent blend that contains either at least dichloromethane (90%) and isopropanol (1%), or a blend that includes sodium hydroxide and cyclohexanone.

Current Screen Reclamation Practices in Facility 2

All screen printing at this facility is done using solvent-based inks. Screen reclamation employees wear gloves and eye protection for all steps of the process; respiratory protection is also used for ink removal. The screen reclamation process is:

- Ink Remover: Card off excess ink at the press. Bring screen to ink removal room and soak screen with solvent spray (from the low pressure spray in the recycling tank). Wipe off the solvent and ink with a squeegee. Wipe the screen and frame with disposable rags. Repeat the application of solvent (spray, wipe and squeegee) if necessary.

- Emulsion Remover: In the reclamation sink, pressure wash both sides of the screen. Dip a rag in the emulsion remover and wipe down the screen with the rag. Pressure wash.

- Haze Remover: Haze remover is used only about once per week. To apply, scrape paste onto the screen with a card and work it into the screen. Pressure wash. On all screens, a degreaser is applied after emulsion removal. Comet cleanser is used as the degreaser. Sprinkle the Comet on the screen surface. Using the emulsion remover-soaked rag, rub the Comet into the screen. Dip the rag in the emulsion remover again and scrub areas with remaining ink. Pressure wash.

General Facility Background for Facility 19

Facility 19 prints graphic overlays, front panels, and membrane switches. They print on plastics, metals, and paper. Their jobs usually run for 5 - 1500 impressions and approximately 70% of their orders are repeat orders. This facility uses solvent-based inks and a direct photo stencil. The alternative system was used on screens with mesh counts ranging

from 156 - 390 threads/inch. Typical screen size in this facility is 30 inches x 33 inches, and approximately 60 - 80 screens are reclaimed daily.

Screen Reclamation Area in Facility 19

Ink removal is done at the presses and screen reclamation is done in a separate area, approximately 35 ft^2 in size, where ventilation is provided through a hood over the back-lit spray booth. During the observer's visit, the average temperature in the facility was 70°F (and 44% relative humidity). Rags used for ink removal are cleaned weekly by a laundry service. Waste water from screen reclamation is filtered prior to disposal.

Current Screen Reclamation Products at Facility 19

At Facility 19, their standard ink remover is a proprietary solvent blend consisting of at least 20% propylene glycol ethers, and petroleum hydrocarbons (<10%). Information on the chemical constituents of their emulsion remover was not available. Their standard haze remover is a proprietary solvent blend which contains sodium hydroxide (<15%).

Current Screen Reclamation Practices in Facility 19

At Facility 19, 10 - 15 screens are cleaned at the same time. The same product is used for ink removal, emulsion removal and haze removal. Screens are reclaimed as follows:

- Ink Remover, Emulsion Remover, and Haze Remover: Card off excess ink at the press. Bring screen to the reclamation area. Rinse screen with pressure washer (2000 - 2500 psi) to remove block out. Spread the reclamation product with a brush onto both sides of the screen. Let sit for approximately 3 - 4 minutes. Pressure rinse. Reapply the product, let sit for about 10 minutes, then pressure rinse. Gloves, eye protection, ear protection and aprons are worn while using this product.

Cost

Table V-160
Method 2: Summary of Cost Analysis for Alternative System Omicron-AE

Cost Element Description		Baseline (Traditional System 4)	Alternative System Omicron-AE	
			Facility 2	Facility 19
Facility Characteristics				
Average screen size (in^2)		2,127	5,663	957
Average # screens/day		6	6	70
Cost Elements per Screen				
Labor	Time spent applying, scrubbing, and removing reclamation products (min)	24.4	40.2	20.7
	Cost ($)	5.33	8.80	4.52
Materials and Equipment	# of rags used	3	16	0
	Cost ($)	0.45	2.43	0
Reclamation Product Use	Ink Remover			
	Average Volume (oz.)	8.0	12.6	2.3
	Cost ($)	0.22	0.96	0.18
	Emulsion Remover			
	Average Volume (oz.)	3.5	7.5	1.3
	Cost ($)	0.13	0.56	0.10
	Haze Remover			
	Average Volume (oz.)	3.0	12.6	2.3
	Cost ($)	0.12	0.89	0.16
Hazardous Waste Disposal	Amount (g)	34	0	0
	Cost ($)	0.02	0	0
Totals				
Total Cost ($/screen)		6.27	13.65	4.96
Normalized[a]		6.27	10.85	5.49
Total Cost ($/year)		9,399	20,470	86,787
Normalized[a]		9,399	16,278	8,240

[a]Normalized values adjust product usage, number of screens cleaned, and number of rags laundered at demonstration facilities to reflect the screen size and number of screens cleaned per day under the baseline scenario. Labor costs, however, are not normalized. Normalization allows a comparison between the baseline and facility results.

Note: For additional information regarding product performance see performance demonstration summaries.

Product System Omicron-AF

Formulation

Ink Remover	Diethylene glycol butyl ether
	Propylene glycol
Emulsion Remover	Sodium periodate
	Ethoxylated nonylphenol
	Water
Haze Remover	Ethoxylated nonylphenol
	Phosphate surfactant
	Alkali/Caustic
	Water

Occupational Exposure

Table V-161
Occupational Exposure Estimates for Alternative System Omicron-AF

System	Inhalation (mg/day)				Dermal (mg/day)	
	I	II	III	IV	Routine	Immersion
Ink Remover						
Diethylene glycol butyl ether	0	0	0	0	984	4590
Propylene glycol	17	0.1	0	0.4	576	2690
Omicron (Emulsion Remover)						
Sodium periodate	0	0	0	0	47	218
Ethoxylated nonylphenol	0	0	0	0	31	146
Water	0	0	0	0	1480	6920
Haze Remover						
Ethoxylated nonphenol	0	0	0	0	16	73
Alkali/Caustic	0	0	0	0	156	728
Phosphate surfactant	0	0	0	0	78	364
Other	0	0	0	0	109	510
Water	0	0	0	0	1200	5610

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry

Table V-162
Occupational Risk Estimates for Alternative System Omicron AF

Name	Hazard Quotient[b]			Margin Of Exposure[a]					
		Dermal		Inhalation		Dermal			
						Routine		Immersion	
	Inhalation	Routine	Immersion	NOAEL[c]	LOAEL[d]	NOAEL	LOAEL	NOAEL	LOAEL
Ink Remover									
Diethylene glycol butyl ether	NA	NA	NA	NA	NA	142	3.6	30	0.8
Propylene glycol	0.01	0.4	1.9	NA	NA	NA	NA	NA	NA
Emulsion Remover									
Sodium periodate	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ethoxylated nonylphenol	NA	NA	NA	NA	NA	NA	NA	NA	NA
Water	NA	NA	NA	NA	NA	NA	NA	NA	NA
Haze Remover									
ethoxylated nonylphenol	NA	NA	NA	NA	NA	NA	NA	NA	NA
Alkali/Caustic	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phosphate surfactant	NA	NA	NA	NA	NA	NA	NA	NA	NA
Water	NA	NA	NA	NA	NA	NA	NA	NA	NA

[a]Margin of Exposure (MOE) values above 100 for a NOAEL and 1000 for a LOAEL indicate low risk.
[b]Hazard Quotient is the ratio of the estimated chronic dose/exposure level to the Reference Dose (RfD) or the Reference Concentration (RfC). Hazard Quotient values less than 1 imply that adverse effects are very unlikely to occur.
[c]NOAEL means No Observed Adverse Effect Level.
[d]LOAEL means Lowest Observed Adverse Effect Level.

Occupational Risk Conclusions and Observations

Ink Remover and Haze Remover

- Margin-of-exposure calculations indicate clear concerns for chronic dermal exposures to workers using diethylene glycol butyl ether in ink removal.

- Margin-of-exposure calculations also show possible concerns for developmental toxicity risks from dermal "immersion" exposures to diethylene glycol butyl ether. Routine dermal exposures, however, represent a very low concern for developmental toxicity risks.

- Hazard quotient calculations for inhalation and dermal exposures to propylene glycol during ink removal indicate very low concern.

- Inhalation exposures to other components are very low.

- Risks from other components could not be quantified because of limitations in hazard data, although dermal exposures to all components could be relatively high.

Emulsion Removers (All Systems)

- All of the systems that employ an emulsion remover use either a strong oxidizer such as hypochlorite or periodate or a strong base such as sodium hydroxide. The haze removers in Alpha, Epsilon, Gamma, Mu, Omicron, and Theta also contain these compounds. All of these materials present a high concern for skin and eye irritation and tissue damage if workers are exposed in the absence of proper protective clothing. None of the emulsion removers present significant inhalation risks.

Environmental Releases

Table V-163
Environmental Release Estimates in Screen Cleaning Operations
Method 2, Alternative System Omicron-AF

System	Release Under Each Scenario (g/day)						
	I			II	III	IV	
	air	water	land	air	air	air	water
Ink Remover							
Diethylene glycol butyl ether	0	0	440	0	0	0	852
Propylene glycol	35	0	222	0.2	0.1	0.7	497
Emulsion Remover							
Sodium periodate	0	19	0	0	0	0	0
Ethoxylated nonylphenol	0	13	0	0	0	0	0
Water	0	603	0	0	0	0	0
Haze Remover							
Ethoxylated nonphenol	0	5.6	0	0	0	0	0
Alkali/Caustic	0	56	0	0	0	0	0
Phosphate surfactant	0	28	0	0	0	0	0
Other	0	43	0	0	0	0	0
Water	0	428	0	0	0	0	0

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry

Environmental Release Estimates from Screen Reclamation Processes
Screen Reclamation Method 2, Alternative System Omicron-AF

From Ink Removal Operations:

Diethylene glycol butyl ether

852 g/day to water from rags at commercial laundry

440 g/day to landfill

Propylene glycol

36 g/day to air

497 g/day to water from rags at commercial laundry

222 g/day to landfill

Environmental Release Estimates from Screen Reclamation Processes
Screen Reclamation Method 2, Alternative System Omicron AF (cont.)

From Emulsion Remover:

Sodium periodate

19 g/day to water

Ethoxylated nonylphenol

13 g/day to water

From Haze Remover:

Other

39 g/day to water

Ethoxylated nonylphenol

5.6 g/day to water

Alkali/caustic

56 g/day to water

Phosphate surfactant

28 g/day to water

Table V-164
Summary of Estimated Daily Environmental Releases from a Hypothetical Facility Using Screen Reclamation Method 2, Alternative System Omicron-AF

Substance:	To Air:	To Water:	To Landfill:
Diethylene glycol butyl ether		852 g/day at laundry	440 g/day
Propylene glycol	36 g/day	497 g/day at laundry	222 g/day
Sodium periodate		19 g/day	
Ethoxylated nonylphenol		18.6 g/day	
Alkali/caustic		56 g/day	
Other		39 g/day	
Phosphate surfactant		28 g/day	

Releases to Water from a Single Facility

Table V-165
Estimated Releases to Water from Traditional Formulations from Screen Reclamation at a Single Facility Using Screen Reclamation Method 2, Alternative System Omicron-AF

Substance	Amount Released to Water from Facility	Waste water Treatment Removal Efficiency	Amount to Water After Waste water Treatment	Daily Stream Concentration, ug/L[a] for 1000 MLD Receiving Water
Diethylene glycol butyl ether	852 g/day at laundry	83 %	145 g/day	1×10^{-1}
Propylene glycol	497 g/day at laundry	97 %	14.9 g/day	1×10^{-2}
Ethoxylated nonylphenol	18.6 g/day	100 %	0	0
Sodium Periodate	19 g/day	100 %	0	0
Other	39 g/day	100 %	0	0
Phosphate surfactant	28 g/day	100 %	0	0
Alkali/caustic	56 g/day	100 %	0	0

[a]ug/L is Micrograms per liter, which is parts per billion for a substance in water. MLD is Million liters per day.

Releases to Air from Individual Screen Printing Facilities

Table V-166
Air Release, Concentration and Potential Dose Estimates from a Single Model Facility Using Screen Reclamation Method 2, Alternative System Omicron-AF

Substance	Amount of Releases per day	Highest Average Concentration 100 M away	Annual Potential Dose, mg/year[a]
Propylene glycol	36 g/day	7.3×10^{-2} ug/m^3	5×10^{-1}

[a]This estimates doses for people living 100 Meters from the hypothetical facility. The actual number of people who would fall into this range can be determined from census data, if the facility location is known. The model used to calculate concentrations is more completely explained in the Overview by Media-Air Section in Chapter III. To calculate the annual potential dose, the concentration is multiplied by the amount a person will breathe (20 m^3/day) and the number of days per year (365), and the units are converted to mg/year by dividing by 1000.

General Population Risk Conclusions and Observations

- Health risks to the general population from both air and water exposures are very low for Method 2, Product System Omicron-AF.

Although air releases were evaluated for only a single facility, it is very unlikely that an analysis of cumulative air releases would lead to different risk conclusions. Examples of general population exposure and risk estimates are shown for Method 2, Traditional System 1 in Methods 1 and 2 and Alternative System Chi in Method 2; please reference these sections as illustrative examples. Hazard Quotient values below one indicate very low risk. Margin-of-Exposure (MOE) values above 100 for a NOAEL or above 1000 for a LOAEL indicate very low risk.

Ecological Risks From Water Releases Of Screen Reclamation Chemicals

- None of the single facility releases of Method 2, Product System Omicron-AF reach an ecotoxicity concern concentration.

Performance

General Summary of System Omicron-AF Performance, and Related Variables

Product System Omicron-AE and Product System Omicron-AF were submitted for demonstration by the same manufacturer. They have the same ink remover and the same emulsion remover, but each one has a different haze remover to complete the system. Although these systems do share a common ink remover and emulsion remover, Omicron-AE and Omicron-AF are each evaluated as a separate Product System in this documentation. It was the intention of the Performance Demonstrations to evaluate reclamation systems as a whole, not individual products, whenever possible.

Product System Omicron-AF is a water-based system and it consisted of an ink remover, an emulsion remover, and a haze remover. A degreaser accompanied this product system, however, detailed information on the performance of the degreaser is not included in the scope of this project. The performance of the product was demonstrated at Facilities 4 and 18. Facility 4 prints decals using UV-curable inks; Facility 18 prints nameplates, panels, and graphic overlays using solvent-based inks. During the demonstration periods, Facility 4 used the alternative system to reclaim 19 screens over a 2 week period and Facility 18 reclaimed 32 screens over 4 weeks. Facility 4 discontinued use of the alternative product system after two weeks, due to the poor performance of the ink remover and the haze remover.

At Facility 4, the ink remover removed the ink from the mesh satisfactorily, however, residue remained in the stencil area on most of the screens. The printer felt the ink residue was minimal, and if he were using his standard haze remover, this residue would not have been a problem. Facility 18 reported that the ink remover worked as well as their standard products.

The emulsion remover worked very well at both facilities. It removed the stencil completely and easily. The haze remover performance was not acceptable at either facility. Facility 4 reported that the haze remover was not effective in removing any of the ink haze, even with vigorous scrubbing and procedural modifications. A ghost image appeared on subsequent print jobs, which required that the printer clean the screens again with his standard product.

At Facility 18, the haze remover left too much haze under all conditions and their standard haze remover had to be used after the alternative system before the screen could be reused. Because of this poor performance, the facility stopped using the haze remover during the first week of demonstrations.

Alternative System Omicron-AF Profile

The manufacturer recommends applying Product System Omicron-AF as follows:

- Ink Remover After carding off as much excess ink as possible, use a spray bottle to apply ink remover to both sides of the screen. Brush the product on the screen surface to loosen the ink on both sides. With a clean cloth, wipe the screen clean. Repeat spraying on the ink remover and wiping it off until the screen is clean.

- Emulsion Remover Place the screen in a washout sink and spray both sides of the stencil with the emulsion remover so that it evenly covers the stencil. Wait one minute. Use a soft brush to loosen the stencil and scrub the screen until the stencil is broken up in all areas. Apply more emulsion remover if necessary. Rinse the screen with a pressure washer (a 1000 psi pressure wash was used at SPTF).

- Haze Remover Pour the haze remover into a bucket. Dip a brush into the bucket and scrub the product into both sides of the screen in the effected areas. Let stand for 1 - 2 minutes. Pressure rinse from the bottom of the screen to the top. Turn the screen around and repeat the pressure rinse from bottom to top on the other side of the screen.

Alternative System Performance at SPTF

Product System Omicron-AF was tested at SPTF on three screens (one with a solvent-based ink, one with a UV-curable ink, and one with a water-based ink). On the screen with the solvent-based ink, the ink dissolved well with moderate effort (5 wipes were used). On the last rag there was a slight blue color (the color of the stencil) which may indicate that the ink remover could deteriorate the stencil. Ink remover performance on the screen with UV-curable ink was similar expect there was some red coloring on the rag as well as blue. The red tint could indicate an effect on the adhesive (which is red) that holds the screen to the frame. The UV-curable ink screen also required moderate effort to remove the ink and 6 rags were used. Compared to the other two screens, the screen with water-based ink required additional time, effort (7 rags), and product to loosen the ink. Also on the water-based ink screen, the technician noted that the ink remover started to deteriorate the stencil.

On all three screens, the emulsion remover dissolved the stencil quickly and with moderate scrubbing effort and the pressure rinse removed it completely. On the screen with solvent-based ink, a moderate ink stain remained on the screen after using the emulsion remover. The UV screen had a lighter stain. The water-based ink screen had a moderate stain with some ink residue remaining in the half-tone area. The haze remover lightened the stains on all three screens and removed the ink residue on the water-based ink screen.

Products were applied according to the manufacturer's recommended application procedure. After using the haze remover, the technician noted that there was a small hole in the screen with solvent-based ink that was not there before using the haze remover.

Alternative System Performance Details

Performance Details from Facility 4

After using Product System Omicron-AF for two weeks, Facility 4 decided they did not want to continue participation in the performance demonstrations. When using the screens reclaimed with Omicron-AF in subsequent print jobs, the printer noticed a ghost image. He cleaned the screens again using his own product to remove the haze and was then able to reuse the screens. Faced with a tight production schedule, the printer was unable to continue using Product System Omicron-AF since additional time would be required to reclean the screens with his standard product.

After using the ink remover, the printer evaluated the screen and reported that the ink was removed effectively on 80% of the screens. However, after using the emulsion remover, the printer noted that on every screen an ink residue remained in the stencil area. He felt that this ink residue normally would not have been a problem, because his haze remover could remove it. The alternative haze remover could not.

The printer was pleased with the performance of the emulsion remover. He reported that it removed the stencil completely and easily.

The performance of the haze remover was unacceptable at this facility. When following the manufacturers application instructions, the haze remover reduced the residue, but did not remove it or significantly lighten the ink stain on the mesh, even after vigorous scrubbing and a long high pressure water wash. A ghost image was clearly visible on subsequent print jobs which required the printer to clean the screen again with his standard haze remover.

To improve the product performance, the printer varied several conditions: he increased the soaking time on the screen for the ink remover and the haze remover, he increased the quantity of ink remover and haze remover, he sprayed the haze remover on a scrubber pad instead of directly onto the screen, and he tried drying the screen before using the haze remover. These techniques did not improve the performance of the product system. During the two weeks of demonstrations, product performance was quite consistent as were the demonstration conditions (e.g., ink type, emulsion type, screen condition). The printer did not think further use of the product would provide any different data.

Overall, the printer did not notice any change in screen failure rate over the time period that the alternative system was in use, however, he did need to clean each screen a second time with his own haze remover in order to be able to reuse it. The printer thought this haze would build up on the screen and would eventually prevent the emulsion from adhering to the screen.

Performance Details from Facility 18

Facility 18 used Product System Omicron-AF for four weeks. The press area supervisor was asked to comment on the performance of the system several times during the performance demonstration period. He felt that, in general, the ink remover and emulsion remover products worked as well as the products they were previously using. The haze remover, however, did not give acceptable results, and they stopped using it during the first week of the demonstrations.

The ink remover worked well in most cases. Two of their solvent-based inks which were difficult to clean with their regular products also required more effort with the alternative system. The facility's standard procedure for these inks is to apply haze remover twice after

reclaiming. Ink residue left by the alternative chemicals required this practice to be continued during the performance demonstration.

The emulsion remover performed well on all screens and stencils. The reclaimer noted that the stencil dissolved easily with this product. The haze remover did not work well. After reclaiming several screens, it was determined that the screens could not be reused until the facility's regular haze remover was applied to them. Facility 18 therefore discontinued the use of the alternative haze remover.

Screen size at this facility was relatively uniform, and careful controls were placed on screen condition and tension. Retensionable frames were used exclusively. The screens were brought to the reclaiming area with most of the ink removed from them already, having been carded off at the press. Facility 18 had tried other products which were advertised as "safer", and they had one bad experience where one of the products damaged their plumbing system. The same person reclaimed the screens and evaluated the print image quality. This employee was knowledgeable about the entire screen printing process.

The products in System Omicron-AF were not observed to be detrimental to the screen mesh, the printing equipment during the performance demonstration. Print image quality was not affected.

Alternative System Performance Table Compiled from Field Sites

The table below highlights the observed performance of the product system and the relevant conditions of the demonstration, as recorded by the printers using the products at the demonstration facilities. In addition to the field demonstration performance data, results of the product tests performed at SPTF are also summarized in this table. More descriptive information on the demonstration facilities is included in the section following the table.

Facility Profiles

General Facility Background for Facility 4

Facility 4 prints decals on plastic sheets. A typical run is 3,000 sheets, and approximately 50% of their orders are repeat orders. Of the 30 - 40 employees at this facility, approximately 4 are involved in screen reclamation. All printing is done with UV-curable inks. All screens used in the Performance Demonstrations were polyester (calendared) with a typical mesh count of 390 threads/inch with a direct photo stencil. The average screen size at this facility is 35 inches x 38 inches and approximately 6 screens are reclaimed daily.

Screen Reclamation Area in Facility 4

The screen printing, ink removal, and screen reclamation activities are all done in the same area of the facility. The ink removal area consists of a work table about 20 feet from the press, and screen reclamation is done in a spray booth nearby. The open plant area with high ceilings and overhead fans provide ventilation for the area. The average temperature during the observer's visit was 73°F (and 35% relative humidity). Rags used for clean up and for ink removal are cleaned by a laundry service. Waste water from the high-pressure wash of the emulsion remover and haze remover is not recycled or filtered at this facility.

Table V-167
On-Site Performance Summary for Alternative System Omicron-AF

		Performance						Demonstration Conditions			
	System Component	Avg Drying Time BeforeUsing Product	Average Quantity Applied	Average Cleaning Time	Average Effort Required	Performance for Each System Component	Overall System Performance	Ink type(s)	Emulsion type	Mesh type; Thread count	Average Screen Size
In-field Demonstrations at Volunteer Printing Facilities											
Facility 4	*Ink remover*	46.1 ± 49.3 hrs (n=22)	1.6 ± 0.7 oz.(n=22)	5.1 ± 0.6 mins (n=12)	Moderate	Ink residue in stencil area.	• Most screens could not be reused due to a haze. • A ghost image appeared when the screens were reused. • The facility discontinued use after 2 weeks.	UV-curable	Direct photo stencil	Monofilament Polyester, calandered; 390 threads/inch	1577 in^2
	Emulsion Remover	5.5 ± 10.2 hrs (n=22)	1.4 ± 0.5 oz. (n=22)	4.9 ± 0.3 mins (n=12)	Low	Easily removed stencil.					
	Haze Remover	4.1 ± 2.0 mins (n=22)	2.1 ± 0.7 oz. (n=12)	5.0 ± 0.2 mins (n=12)	High	Did not remove ghost image from most screens.					
Facility 18	*Ink Remover*	28.5 ± 28.0 hrs (n=47)	2.2 ± 0.5 oz. (n=46)	2.7 ± 0.9 mins (n=46)	Low	Removed ink well.	• Facility was pleased with the ink and emulsion removers. • They switched back to their own haze remover after one week.	Solvent-based	Direct photo stencil and capillary film	Mono-filament polyester; 110 - 460 threads/inch	1150 in^2
	Emulsion Remover	1.2 ± 1.1 mins (n=47)	3.6 ± 1.2 oz. (n=47)	4.0 ± 1.1 mins (n=47)	Low	Easily removed stencil.					
	Haze Remover	0.8 ± 2.7 mins (n=47)	1.9 ± 0.7 oz. (n=11)	4.1 ± 1.4 mins (n=11)	Low	Did not reduce haze.					

Table V-168
Laboratory Performance Summary for Alternative System Omicron-AF

		Performance						Demonstration Conditions			
	System Component	Avg Drying Time Before Using Product	Average Quantity Applied	Average Cleaning Time	Average Effort Required	Performance for Each System Component	Overall System Performance	Ink type(s)	Emulsion type	Mesh type; Thread count	Average Screen Size
SPTF Solvent-based Ink	*Ink Remover*	15 mins	1.5 oz.	5.7 mins	Moderate	Ink dissolved well.		Solvent-based	Dual cure direct	Polyester; 260 threads/inch	360 in^2
	Emulsion Remover	24 hours	1.0 oz.	4.1 mins	Moderate	Stencil dissolved easily. Moderate ink stain remaining.					
	Haze Remover	0 mins	1.0 oz.	4.0 mins	Low	Lightened the ink stain.					
SPTF UV-curable Ink	*Ink Remover*	15 mins	1.5 oz.	6.5 mins	Low	Ink dissolved well.		UV-curable	Dual cure direct	Polyester; 390 threads/inch	360 in^2
	Emulsion Remover	24 hours	1.0 oz.	4.1 mins	Low	Stencil dissolved easily. Light ink stain remaining.					
	Haze Remover	0 mins	0.5 oz.	4.5 mins	Low	Lightened the ink stain.					
SPTF Water-based Ink	*Ink Remover*	15 mins	2.5 oz.	7.8 mins	Moderate	Ink dissolved with extra effort and product.		Water-based	Dual cure direct	Polyester; 260 threads/inch	360 in^2
	Emulsion Remover	24 hours	1.0 oz.	4.4 mins	Moderate	Stencil dissolved easily. Some ink residue remaining.					
	Haze Remover	0 mins	1.0 oz.	4.2 mins	Low	Removed residue; lightened stain.					

Current Screen Reclamation Products at Facility 4

As their standard screen reclamation products, Facility 4 uses two proprietary products for ink removal, and also uses proprietary products for emulsion and haze removal. These products are sold by a manufacturer not participating in the performance demonstration. The MSDSs for all of these products state that they contain no carcinogens, no ingredients with TLVs or PELs, and no petroleum derivatives.

Current Screen Reclamation Practices in Facility 4

Screen reclamation employees wear eye protection for all steps of the process; gloves and barrier cream are also available. The reclamation process is described below:

- Ink Remover: Card off excess ink at the press. Spray on the in-process ink remover and wipe the screen with a reusable rag. Bring the screen over to the ink removal area and place the screen flat on the table. Wipe with a sponge, then, using a squeegee on both sides, pull the residue down to the bottom of the screen. Use a rag to wipe off the residue. One rag is used for every two or three screens. Bring the screen over to the pressure wash booth. From a five-gallon container, spray both sides of the screen with the ink degradent. Use a scrubber pad to rub the product into the screen. Pressure wash (1000 psi) both sides of the screen to rinse out the ink and blockout, and also to loosen the masking tape around the edges of the frame.

- Emulsion Remover: Spray both sides of the screen with emulsion remover from a five-gallon container. Brush the stencil area on both sides with a scrubber pad. Rinse the both sides of the screen with a high pressure wash.

- Haze Remover: Haze remover is used on all screens being reclaimed. Spray on haze remover from a 24 ounce spray bottle. Scrub the effected area with a scrubber pad. Wait for one minute and rinse with a pressure wash.

General Facility Background for Facility 18

Facility 18 prints graphic overlays for the electronics industry and nameplates and panels. All of their printing is done on plastics. Their typical run length is 16 hours and approximately 80% of their orders are repeat orders. There are approximately 40 employees at this facility, three of which are involved in screen reclamation activities. During the Performance Demonstration, this facility used solvent-based inks and they used both a direct photo stencil and a capillary film stencil. High tension monofilament polyester mesh (untreated) screens with mesh counts ranging from 110 - 460 threads/inch were used. Typical screen sizes in this facility are 1,596 in^2 or 952 in^2, and approximately 10 - 15 screens are reclaimed daily.

Screen Reclamation Area in Facility 18

Ink removal and screen reclamation operations are both done within the screen printing area of the facility where local ventilation is provided. The ink removal area consists of a work table and a spray booth. A second spray booth is used for reclamation; this booth is back-lit and is separated from the ink removal booth by a stainless steel sink. During the observer's visit, the average temperature in both areas was 65°F (and 49% relative humidity). In the ink removal area, a filtration system is used to filter and recirculate the ink remover solvent. These

filters are disposed of as hazardous waste along with the used shop rags. Waste water from the washes of the emulsion remover and haze remover is not recycled or filtered at this facility.

Current Screen Reclamation Products at Facility 18

As their standard ink remover, Facility 18 uses a proprietary solvent blend that contains at least pentanedioic acid and dimethyl ester (<20%). Their standard emulsion remover is a proprietary aqueous mixture with at least sodium periodate. For haze removal, this facility uses a proprietary aqueous mixture that contains sodium hydroxide (<15%).

Current Screen Reclamation Practices in Facility 18

At Facility 18, screens are reclaimed as follows:

- Ink Remover: Spray on the ink remover from the recirculation tank through a manual pressurized brush system. Rub the screen with a scrubber pad on both sides of the screen. Spray both sides of the screen with low pressure water. Gloves, eye protection, and aprons are worn during ink removal.

- Emulsion Remover: Spray on the emulsion remover and let it sit for approximately 30 seconds. Rinse with a high pressure (1500 psi) wash. Blow dry the screen with compressed air, then vacuum dry the screen, and blow with compressed air again until the screen is completely dry. Gloves, eye protection, aprons, respiratory protection, and ear protection are used during emulsion removal.

- Haze Remover: Dip a scrubber pad into the container of haze remover. Rub the product into the screen. Allow the screen to drain then bring it to another tub and let sit to dry for 30 minutes. Apply ink remover from the recirculation tank and let sit for 5 minutes. Allow the screen to drain into recirculation tank. Bring the screen over to the spray booth and spray with a low pressure spray followed by a high pressure wash.

Cost

Table V-169
Method 2: Summary of Cost Analysis for Alternative System Omicron-AF

Cost Element Description		Baseline (Traditional System 4)	Alternative System Omicron-AF	
			Facility 4	Facility 18
Facility Characteristics				
Average screen size (in^2)		2,127	1,210	1,150
Average # screens/day		6	6	13
Cost Elements per Screen				
Labor	Time spent applying, scrubbing, and removing reclamation products (min)	24.4	15.0	10.8
	Cost ($)	5.33	3.28	2.37
Materials and Equipment	# of rags used	3	1.3	1.3
	Cost ($)	0.45	0.20	0.20
Reclamation Product Use	Ink Remover Average Volume (oz.)	8.0	1.6	2.2
	Cost ($)	0.22	0.12	0.17
	Emulsion Remover Average Volume (oz.)	3.5	1.4	3.6
	Cost ($)	0.13	0.10	0.27
	Haze Remover Average Volume (oz.)	3.0	2.1	1.9
	Cost ($)	0.12	0.15	0.14
Hazardous Waste Disposal	Amount (g)	34	0	0
	Cost ($)	0.02	0	0
Totals				
Total Cost ($/screen)		6.27	3.86	3.14
Normalized[a]		6.27	4.45	3.89
Total Cost ($/year)		9,399	5,784	9,823
Normalized[a]		9,399	6,675	5,836

[a]Normalized values adjust product usage, number of screens cleaned, and number of rags laundered at demonstration facilities to reflect the screen size and number of screens cleaned per day under the baseline scenario. Labor costs, however, are not normalized. Normalization allows a comparison between the baseline and facility results.

Note: For additional information regarding product performance see performance demonstration summaries.

Product System Zeta

Formulation

Ink Remover	Propylene glycol series ethers
Emulsion Remover	Sodium periodate
	Water
Haze Remover	Alkali/Caustic
	Propylene glycol
	Water

Occupational Exposure

Table V-170
Occupational Exposure Estimates for Alternative System Zeta

System	Inhalation (mg/day)				Dermal (mg/day)	
	I	II	III	IV	Routine	Immersion
Ink Remover						
Propylene glycol series ethers	139	0.6	0	2.8	1560	7280
Emulsion Remover (diluted 1:4)						
Sodium periodate	0	0	0	0	16	73
Water	0	0	0	0	1540	7210
Haze Remover						
Alkali/Caustic	0	0	0	0	234	1090
Propylene glycol	0	0.1	0	0	62	291
Water	0	0	0	0	1260	5900

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry

Occupational Risk Conclusions and Observations

Ink Remover and Haze Remover

- Hazard quotient calculations indicate marginal concerns for chronic inhalation exposure to workers using propylene glycol series ethers in ink removal. Possible concerns also exist for chronic dermal exposure to propylene glycol series ethers based on the calculated hazard quotients, which assume 100% dermal absorption. If the actual dermal absorption rate of propylene glycol series ethers is significantly lower, this concern would be significantly reduced or eliminated.

Table V-171
Occupational Risk Estimates for Alternative System Zeta

Name	Hazard Quotient[b]			Margin Of Exposure[a]					
		Dermal		Inhalation		Dermal			
						Routine		Immersion	
	Inhalation	Routine	Immersion	NOAEL[c]	LOAEL[d]	NOAEL	LOAEL	NOAEL	LOAEL
Ink Remover									
Propylene glycol series ethers	3.2	18	87	NA	100	NA	NA	NA	NA
Emulsion Remover (diluted 1:4)									
Sodium periodate	NA	NA	NA	NA	NA	NA	NA	NA	NA
Water	NA	NA	NA	NA	NA	NA	NA	NA	NA
Haze Remover									
Alkali/Caustic	NA	NA	NA	NA	NA	NA	NA	NA	NA
Propylene glycol	0.1	0.04	0.2	NA	NA	NA	NA	NA	NA
Water	NA	NA	NA	NA	NA	NA	NA	NA	NA

[a]Margin of Exposure (MOE) values above 100 for a NOAEL and 1000 for a LOAEL indicate low risk.
[b]Hazard Quotient is the ratio of the estimated chronic dose/exposure level to the Reference Dose (RfD) or the Reference Concentration (RfC). Hazard Quotient values less than 1 imply that adverse effects are very unlikely to occur.
[c]NOAEL means No Observed Adverse Effect Level.
[d]LOAEL means Lowest Observed Adverse Effect Level.

- Inhalation exposures to propylene glycol series ethers also present possible concerns for developmental toxicity risks, based on margin-of-exposure calculations.

- Hazard quotient calculations for chronic inhalation and dermal exposures to propylene glycol during haze removal indicate very low concern.

- Inhalation exposures to other components are very low.

- Risks from other ink remover and haze remover components could not be quantified because of limitations in hazard data, although dermal exposures to all components could be relatively high.

Emulsion Removers (All Systems)

- All of the systems that employ an emulsion remover use either a strong oxidizer such as hypochlorite or periodate or a strong base such as sodium hydroxide. The haze removers in Alpha, Epsilon, Gamma, Mu, Omicron, and Theta also contain these compounds. All of these materials present a high concern for skin and eye irritation and tissue damage if workers are exposed in the absence of proper protective clothing. None of the emulsion removers present significant inhalation risks.

Environmental Releases

Table V-172
Environmental Release Estimates in Screen Cleaning Operations
Method 2, Alternative System Zeta

System	Release Under Each Scenario (g/day)						
	I			II	III	IV	
	air	water	land	air	air	air	water
Ink Remover							
Propylene glycol series ethers	290	0	375	1.4	0.8	5.8	1345
Emulsion Remover (diluted 1:4)							
Sodium periodate	0	6	0	0	0	0	0
Water	0	615	0	0	0	0	0
Haze Remover							
Alkali/Caustic	0	80	0	0	0	0	0
Propylene glycol	0.7	21	0	0.2	0.1	0	0
Water	0	431	0	0	0	0	0

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry

Table V-173
Summary of Estimated Daily Environmental Releases from a Hypothetical Facility Using Screen Reclamation Method 2, Alternative System Zeta

Substance:	To Air:	To Water:	To Landfill:
Propylene glycol series ethers	297.6 g/day	1345 g/day at laundry	375 g/day
Sodium periodate		6 g/day	
Alkali/caustic		80 g/day	
Propylene glycol	1 g/day	21 g/day	

Releases to Water from a Single Facility

Table V-174
Estimated Releases to Water from Traditional Formulations from Screen Reclamation at a Single Facility Using Screen Reclamation Method 2, Alternative System Zeta

Substance	Amount Released to Water from Facility	Waste water Treatment Removal Efficiency	Amount to Water After Waste water Treatment	Daily Stream Concentration, ug/L[a] for 1000 MLD Receiving Water
Propylene glycol series ethers	1375 g/day	83-97 %	222 g/day	2×10^{-1}
Sodium periodate	6 g/day	100 %	0	0
Alkali/caustic	80 g/day	100 %	0	0
Propylene glycol	21 g/day	97 %	0.6 g/day	6×10^{-4}

[a]ug/L is Micrograms per liter, which is parts per billion for a substance in water. MLD is Million liters per day.

Releases to Air from Individual Screen Printing Facilities

Table V-175
Air Release, Concentration and Potential Dose Estimates from a Single Model Facility Using Screen Reclamation Method 2, Alternative System Zeta

Substance	Amount of Releases per day	Highest Average Concentration 100 M away	Annual Potential Dose, mg/year[a]
Propylene glycol series ethers	297.6 g/day	6.1×10^{-1} ug/M3	4
Propylene glycol	21 g/day	4.3×10^{-2} ug/m^3	3×10^{-1}

[a]This estimates doses for people living 100 Meters from the hypothetical facility. The actual number of people who would fall into this range can be determined from census data, if the facility location is known. The model used to calculate concentrations is more completely explained in the Overview by Media-Air Section in Chapter III. To calculate the annual potential dose, the concentration is multiplied by the amount a person will breathe (20 m^3/day) and the number of days per year (365), and the units are converted to mg/year by dividing by 1000.

General Population Risk Conclusions and Observations

- Health risks to the general population from both air and water exposures are very low for Method 2, Product System Zeta.

Although air releases were evaluated for only a single facility, it is very unlikely that an analysis of cumulative air releases would lead to different risk conclusions. Examples of general population exposure and risk estimates are shown for Method 2, Traditional System 1 in Methods 1 and 2 and Alternative System Chi in Method 2; please reference these sections as illustrative examples. Hazard Quotient values below one indicate very low risk. Margin-of-Exposure (MOE) values above 100 for a NOAEL or above 1000 for a LOAEL indicate very low risk.

Ecological Risks From Water Releases Of Screen Reclamation Chemicals

- None of the single facility releases of Method 2, Product System Zeta reach an ecotoxicity concern concentration.

Performance

General Summary of Product System Zeta Performance, and Related Variables

This product system consisted of an ink remover, emulsion remover, and a haze remover. The performance of the products was demonstrated at Facilities 6, 7, and 15. Facility 6 prints store displays, traffic markings, and movie posters; Facility 7 prints decals, labels, vehicle markings, and store displays; Facility 15 prints plexiglass displays, store displays, and banners. During the demonstration period, Facility 6 reclaimed seven screens, Facility 7 reclaimed four screens, and Facility 15 reclaimed eight screens. Facility 6 used solvent, ultraviolet (UV)-cured, and water-based inks; Facility 7 and Facility 15 used solvent-based and UV-cured inks.

Facility 6 reported that the performance of the alternative ink remover was poor, and they had to reclean their screens using their standard ink remover after the alternative product. Although the ink remover performed poorly with solvent and UV-cured inks in general, Facility 6 reported that the alternative ink remover worked well on one screen with water-based inks and on one with UV-cured ink. Facility 7 reported that for solvent-based inks, the ink remover seemed to dry on the screen and did not take the ink out; the alternative ink remover did work well with UV-cured inks. To improve performance of the ink remover, the screen reclamation employee needed to begin wiping the ink remover off the screen immediately after spraying instead of waiting, as recommended. If the ink remover was not wiped off immediately, it dried on the screen and then they needed to use their regular ink remover. Facility 15 reported that the ink remover did not work at all for this facility; it had to be applied a number of times and, even with more scrubbing than usual, it had to be followed with their standard product.

Both Facility 6 and Facility 7 found the emulsion remover did not work well when diluted with five parts water. When the facilities increased the emulsion remover concentration by diluting with only three parts water, the emulsion remover dissolved the stencil. At Facility 6, the performance of the emulsion remover was not consistent, even at the stronger concentration. Facility 7 was generally pleased with the performance of the emulsion remover at the stronger concentration, however, they still had problems if the emulsion remover was permitted to dry in the mesh. Facility 15 reported that the emulsion remover was passable, but the facility still preferred their own product. The alternative emulsion remover required extra scrubbing effort (even at full strength) at Facility 15.

All three facilities reported that the haze remover did not have any effect on the haze. They all had to use their own haze remover in many cases. These facilities did not reclaim many screens using the Product System Zeta for several reasons: they were disappointed and discouraged by the early results, the products arrived later then expected and the observer was not present to assist the printers with the application procedure or to offer suggestions for improving performance, and the production schedules of the shops was unusually busy. Because of these factors, none of the facilities put extensive effort into attempting to alter application techniques to make the products work at their shop.

Alternative System Zeta Profile

The manufacturer recommends applying Product System Zeta as follows:

- Ink Remover Card off the extra ink left in the screen. Using a spray bottle, apply the ink remover to both sides of the screen. Allow up to 2 minutes for penetration. Squeegee or wipe soaked ink into waste bin. Rinse with high pressure water (a pressure spray of 1000 psi was used at SPTF).

- Emulsion Remover Depending on conditions, dilute one part emulsion remover with up to 5 parts of water. Using a spray bottle, apply the emulsion remover to both sides of the screen and work it in with a nylon mesh pad or brush. Wait one minute and do not allow the mixture to dry on the screen. Rinse both sides of the screen with high pressure water.

- Haze Remover Spray the haze remover thoroughly and evenly onto both sides of screen. Allow at least 15 minutes for normal penetration. Overnight soaking will not damage the screen. Scrub with a synthetic brush or pad. Rinse both sides of screen with high pressure wash.

Alternative System Performance at SPTF

Product System Zeta was tested at SPTF on three screens (one with a solvent-based ink, one with a UV-curable ink, and one with a water-based ink). The ink remover performance varied depending on the type of ink used. The emulsion remover and haze remover performance was consistent for all three screens.

On all three screens, the modifications were made to the manufacturer's instructions for applying ink remover. First, the technician applied the ink remover following the recommended method (spray on both sides of the screen, wait two minutes, squeegee off ink, and rinse with pressure washer). This application method did not satisfactorily remove the ink from any of the three screens. To improve the ink remover performance, the technician reapplied the product using a different method. For the second ink remover application, the technician wiped the screen with a dry rag to remove excess water, sprayed more ink remover over the entire screen, and wiped with rags until the rag was no longer picking up the ink. On the screen with solvent-based ink, the screen had some spots of ink residue and a medium gray haze after the first ink remover application. The stencil was affected in the half-tone area and it turned a light blue color in some areas. A second application of ink remover on the solvent-based ink screen removed the ink residue, but the stencil color came up on the rag. Four rags were used. On the screen with the UV ink, after the first ink remover application procedure, there was a heavy gray stain over the entire screen, ink residue remained in some areas, and the stencil had a dull finish. After the second application of the ink remover, the screen still had some ink stains remaining, but the gray haze was removed. Three rags were used. On the water-based ink screen, after the first application of ink remover was squeegeed off, ink residue remained, mainly on the emulsion. The ink wiped off easily when the ink remover was applied again. The rag was blue with the emulsion from the half-tone areas. Two rags were used.

On all three screens, the stencil dissolved easily with moderate scrubbing. A moderate ink stain remained on all of the screens, but there was no stencil stain or ink residue. The haze remover did not appear to lighten the ink stain on any of the screens. The technician also noted that the odor of the haze remover was so strong, she felt an exhaust fan or a respirator was required. Overall, although an ink stain remained on the screens, SPTF did not think the stain would affect future print quality and therefore, evaluated the product system as acceptable.

Alternative System Performance Details

Performance Details from Facility 6

This facility had mixed success with System Zeta. The demonstrations were complicated by the fact that the screen reclaimers spoke almost no English and the forms had to be translated into Spanish. Two different reclaimers participated in the demonstrations, but another person was involved to either translate the reclaimer's forms or to write down results. Because of this situation, the observer was not confidant that all the information received was accurate. Another confounding factor was that the product arrived late at the facility and the observer was not present to assist the printer with the application instructions and with trouble-shooting, as was done at most other facilities. It is possible that better results could have been achieved had the observer been present.

At Facility 6, the ink remover did not work as well as their usual product. During the demonstrations, this facility used the alternative system on screens with solvent-based, UV-curable, and water-based inks. The alternative ink remover performed poorly with solvent-

based inks, it worked well on one screen with water-based inks, and performance was mixed on screens with UV-inks. Facility 6 needed to use their regular remover to get the ink out of several of the screens after using the alternative ink remover.

This facility had mixed results with the emulsion remover. In general, when the emulsion remover was used at a strength of three parts of product to one part water, or stronger, the stencil dissolved quickly. At weaker concentrations, the emulsion remover worked much more slowly than their usual product and the printer needed to use their usual emulsion remover to get the screens clean. However, these results were not consistent, and on some screens where the stronger formulation was used, the stencil did not dissolve completely.

The haze remover worked very poorly for this facility. It did not seem to reduce haze produced by UV-cured or solvent-based inks and it was not used with water-based inks.

Performance Details from Facility 7

The alternative system arrived at Facility 7 during a very busy period. The facility's initial response to the alternative system's performance was negative. The poor initial performance combined with increased activity at the facility led to a situation where little information was collected on alternative system performance. This facility also received the alternative system shipment late and the observer did not have the opportunity to assist the printer with the application technique or to suggest procedures to improve performance. This assistance was given through telephone conversations between the observer and the facility contact, however, this may not have been as effective as in-person support.

The ink remover performance at Facility 7 was poor. The facility was particularly unhappy with the directions which said to let the ink remover sit on the screen. The ink remover dried quickly into the screens, stuck into the mesh and it was then completely ineffective at removing ink. This facility was only able to use the ink remover if they applied additional ink remover and began wiping it out of the mesh immediately. These changes improved the performance of the ink remover slightly, but often the facility used their usual ink remover to remove all ink from the screens. Facility 7 did use the ink remover on one screen with UV ink and found it worked much better. As their standard ink remover, this facility uses a lacquer thinner in some cases. Adverse interactions could occur when using the alternative ink remover because its chemical composition is very different from lacquer.

Initially, the facility diluted one part emulsion remover to five parts water. At this concentration, the emulsion remover did not dissolve the stencil unless the product was reapplied. When they changed the dilution to one part emulsion remover to three parts water, the stencil dissolved easily with little scrubbing effort. The facility did have problems with the emulsion remover drying quickly into the mesh. Wiping the emulsion remover immediately off of the screen aided the product's performance.

The haze remover was not effective at this facility; they did not think that the haze remover worked at all. Facility 7 only filled in the haze remover information on the data sheets for one screen, although they tried it on several screens and the performance was consistently disappointing.

Performance Details from Facility 15

Facility 15 did not like System Zeta compared to their usual products. Under most conditions, they were unhappy with the performance of the alternative system. Because the alternative system did not work well, the facility recleaned their screens with their usual

products after each demonstration. This double cleaning greatly increased the time required for screen reclamation. Each time the facility tried the alternative system, their confidence in the product's abilities to clean the screen decreased making it even harder to convince the facility to continue with the demonstrations. They submitted data on only eight screens.

The ink remover did not effectively remove the ink from the screens unless it was applied several times. Compared to their standard product, more scrubbing was required and the facility often had to follow up with their usual ink remover to get the ink out of the screens. The standard ink remover is very different chemically than the alternative product. This difference may cause adverse chemical interactions.

At Facility 15, the emulsion remover had to be applied multiple times to effectively clean the screens. Using the emulsion remover undiluted did not eliminate the need for a second application to remove all emulsion from the screen. Even with multiple applications of the undiluted emulsion remover, Facility 15 often had to use their usual emulsion remover to get the screens to the level of cleanliness that they wanted.

The haze remover required harder scrubbing than their usual product and did not seem to reduce the haze. Once again, Facility 15 had to resort to using their usual haze remover to reduce the haze to an acceptable level.

The performance of the alternative system did not seem to be affected by the types of ink or by ink color, although there was a possibility that the alternative system worked slightly better with UV-cured inks than with solvent-based inks. Since the data available was so limited, it is not possible to draw any conclusions on correlations between product performance variations and screen conditions. No screen side effects were noticed during the performance demonstrations, although increased scrubbing will produce a greater level of mesh abrasion, which may in turn lead to higher screen failure rates.

Alternative System Performance Table Compiled from Field Sites

The following table highlights the observed performance of the product system and the relevant conditions of the demonstration, as recorded by the printers using the products at the demonstration facilities. In addition to the field demonstration performance data, results of the product tests performed at SPTF are also summarized in this table. More descriptive information on the demonstration facilities is included in the section following the table.

Facility Profiles

General Facility Background for Facility 6

Facility 6 prints store displays, transit markings, and movie posters on plastics and paper. Their typical run length is 250 - 300 sheets, and approximately 5% of their orders are repeat orders. Of the approximately 25 employees at this facility, 1 - 3 are involved in screen reclamation. Currently, they used solvent-based, water-based, and UV inks, but they are in the process of discontinuing their use of solvent-based ink systems. All screens used in the Performance Demonstrations were made of a polyester mesh with thread counts ranging from 280 - 420 threads/inch. The average screen size used at this facility is 35 ft^2 and 10 - 15 screens are reclaimed daily.

Table V-176
On-Site Performance Summary For Alternative System Zeta

		Performance						Demonstration Conditions			
	System Component	Avg Drying Time Before Using Product	Average Quantity Applied	Average Cleaning Time	Average Effort Required	Performance for Each System Component	Overall System Performance	Ink type(s)	Emulsion type	Mesh type; Thread count	Average Screen Size
Facility 6	*Ink remover*	24.0 ± 15.2 hrs (n=6)	8.3 ± 8.2 oz. (n=6)	2.8 ± 1.3 mins (n=6)	Moderate	Ink residue in screen.	• Only 7 screens were reclaimed at this facility. • They did not use the products because of poor performance.	Solvent-based, UV ink, and water-based inks	Direct photo stencil	Polyester, no treatment; 280 - 420 threads/inch	3926 in^2
	Emulsion remover	12.0 ± 13.8 hrs (n=4)	6.5 ± 2.5 oz. (n=4)	4.8 ± 3.8 mins (n=4)	Moderate/ High	Worked well sometimes, but inconsistent results.					
	Haze remover	11.5 ± 2.5 mins (n=4)	2.8 ± 1.0 oz. (n=4)	2.2 ± 0.5 mins (n=4)	Moderate	Seemed to have no effect on haze.					
Facility 7	*Ink remover*	3.6 ± 1.0 mins (n=4)	8.5 ± 4.5 oz. (n=4)	4.8 ± 1.3 mins (n=4)	Moderate	Dried into the screen mesh and did not remove ink effectively.	• Only 4 screens were reclaimed at this facility. • They did not use the products because of poor performance.	Solvent-based and UV inks	Capillary film	Polyester, abraded; 230 - 390 threads/inch	3060 in^2
	Emulsion Remover	3.8 ± 7.5 hrs (n=4)	1.3 ± 0.5 oz. (n=4)	1.2 ± 0.5 mins (n=4)	Low	Reapplication of product needed to remove stencil.					
	Haze Remover	0.0 ± 0.0 mins (n=4)	2.0 oz. (n=1)	15.0 mins (n=1)	High	Seemed to have no effect on haze.					
Facility 15	*Ink Remover*	10.2 ± 21.1 hrs (n=5)	3.0 ± 0.9 oz. (n=6)	6.2 ± 5.3 mins (n=6)	Low	A lot of product was required to remove the ink.	• This facility had to use their standard products before the screens could be reused. • They reclaimed 8 screens before dropping out of the performance demonstrations	Solvent-based and UV inks	Direct photo stencil	Polyester; 156 - 305 threads/inch	2084 in^2
	Emulsion Remover	13.3 ± 21.5 hrs (n=8)	4.1 ± 2.7 oz. (n=8)	6.5 ± 4.0 mins (n=8)	High	Stencil dissolved slowly with extra scrubbing effort.					
	Haze Remover	1.5 ± 2.0 mins (n=6)	2.3 ± 0.5 oz. (n=6)	20.2 ± 14.9 mins (n=6)	Moderate	Seemed to have no effect on haze.					

Table V-177
Laboratory Performance Summary For Alternative System Zeta

	System Component	Performance						Demonstration Conditions			
		Avg Drying Time Before Using Product	Average Quantity Applied	Average Cleaning Time	Average Effort Required	Performance for Each System Component	Overall System Performance	Ink type(s)	Emulsion type	Mesh type; Thread count	Average Screen Size
SPTF Solvent-based Ink	*Ink Remover*	15 mins	2.5 oz.	6.0 mins	High	2 applications required to remove ink; stencil deteriorated in areas.		Solvent-based	Dual cure direct	Polyester; 260 threads/inch	360 in^2
	Emulsion Remover	24 hours	1.0 oz.	4.3 mins	Moderate	Stencil dissolved easily; some ink stain left.					
	Haze Remover	0 mins	1.0 oz.	16.6 mins	Low	Did not appear to lighten haze at all; strong odor.					
SPTF UV-curable Ink	*Ink Remover*	15 mins	1.0 oz.	4.6 mins	High	2 applications required to remove ink; stains in some spots.		UV-curable	Dual cure direct	Polyester; 390 threads/inch	360 in^2
	Emulsion Remover	24 hours	1.5 oz.	4.5 mins	Moderate	Stencil dissolved easily; some ink stain left.					
	Haze Remover	0 mins	1.0 oz.	17.3 mins	Low	Did not appear to lighten haze at all; strong odor.					
SPTF Water-based Ink	*Ink Remover*	15 mins	1.5 oz.	5.7 mins	High	2 applications required to remove ink; stencil deteriorated in areas.		Water-based	Dual cure direct	Polyester; 260 threads/inch	360 in^2
	Emulsion Remover	24 hours	1.5 oz.	4.5 mins	Moderate	Stencil dissolved easily; some ink stain left.					
	Haze Remover	0 mins	1.0 oz.	16.9 mins	Low	Did not appear to lighten haze at all; strong odor.					

Screen Reclamation Area in Facility 6

Screen reclamation is done in a reclamation room near the main production area. The open area provides ventilation for screen reclamation activities and hoods are being added over the reclamation spray booth. The average temperature during the observer's visit was 71°F (and 45% relative humidity). Waste water from ink removal activities is filtered and the filters are disposed of as hazardous waste. Waste water from the high-pressure wash of the emulsion remover and haze remover is not filtered.

Current Screen Reclamation Products at Facility 6

Facility 6 uses a proprietary blend which contains propylene glycol ethers (<50%) as their standard ink remover. Their emulsion remover is a proprietary aqueous mixture with periodate salt (<10%). For haze removal, they use a proprietary blend consisting of at least sodium hydroxide, potassium hydroxide and propylene glycol ether.

Current Screen Reclamation Practices in Facility 6

The screen reclamation process at Facility 6 is described below. Gloves, eye protection, aprons, respiratory protection, barrier cream, and ear protection are available to all employees involved in screen reclamation.

- Ink Remover: Card off the excess ink at the press. Bring the screen to the reclamation room and spray the ink remover onto the screen at 80 psi from a 55 gallon drum with a nozzle. Squeegee off the ink. Spray the screen and squeegee it again. Pressure wash (2500 psi) both sides of the screen.

- Emulsion Remover: Spray both sides of the screen with the emulsion remover and let sit for a few seconds. Pressure wash the screen. Spray more ink remover onto both sides of the screen and let sit for one minute. Rinse with a high pressure washer, followed by a low pressure water rinse. Allow the screen to air dry.

- Haze Remover: Dip a brush into the container of haze remover and work it into both sides of the screen with the brush or with a scrubber pad. Let sit for three to five minutes then rinse with a high pressure wash, followed by a low pressure rinse.

General Facility Background for Facility 7

Facility 7 prints roll labels, fleet markings, point of purchase displays, and decals. A typical run length is 275 sheets. There are less than 5 screen printing employees at this facility. The facility uses both UV ink and solvent-based ink. During the Performance Demonstrations they used a capillary film emulsion and the screen mesh was an abraded polyester. Mesh counts ranged from 230 - 390 threads/inch. The screen size typically used in this facility is 60" x 52", and 10 - 12 screens are reclaimed daily.

Screen Reclamation Area in Facility 7

Ink removal and screen reclamation are done in separate spray booths located next to each other in the plant. Ventilation for both areas is provided by local overhead fans and ventilated hoods. During the observer's visit, the average temperature in the area was 71°F (and 41% relative humidity). Rags used for screen reclamation activities are cleaned by a

laundry service. Used ink removal solvents are recycled on-site and the recycled product is used in-house. Filtered waste from ink removal is disposed of as a hazardous water. Waste water from emulsion removal and haze removal activity is not filtered at this facility.

Current Screen Reclamation Products at Facility 7

For ink removal, Facility 7 uses lacquer thinner, as well as a proprietary product sold by a manufacturer not participating in the performance demonstration. The MSDS states that this product contains no carcinogens, no ingredients with TLVs or PELs, and no petroleum derivatives. Their standard emulsion remover is a proprietary aqueous mixture which contains periodate salt (<10%). As a haze remover, they use a proprietary aqueous mixture with sodium hydroxide (<15%).

Current Screen Reclamation Practices in Facility 7

Employees wear gloves and eye protection during ink removal and screen reclamation. Respiratory protection is also available for haze removal. Facility 7 screens are reclaimed as follows:

- Ink Remover: Card off the excess ink at the press. On screens that have been printed with clear inks, spray lacquer thinner on both sides of the screen and wipe with reusable rags (two or three rags are used on each screen). The lacquer thinner is recycled. Bring the screen to the ink removal station and spray with ink remover on the squeegee side. Wipe off ink residue with a reusable rags. Repeat application of the ink remover and wipe the screen. Bring the screen to the pressure wash station and rinse both sides of the screen.

- Emulsion Remover: Spray on emulsion remover and work it into the screen with a scouring pad. Pressure rinse the screen and allow to dry in front of the fan.

- Haze Remover: Haze remover is only used on approximately 1 screen per month. To apply, dip a rag or brush into the haze remover, work it into the screen, then rinse with the pressure washer.

General Facility Background for Facility 15

Facility 15 prints store fixtures, banners and point-of-purchase displays. They primarily print on plastics, but they also do some jobs on paper, metal, and wood. A typical run is 800 sheets and 70% of their orders are repeat orders. Of the approximately 5 employees involved in screen printing at this facility, 2 are involved in screen reclamation activities. Several different types of ink are commonly used at Facility 15, including vinyls, epoxies and UV-curable inks. All screens used in the Performance Demonstrations were polyester and a direct photo stencil emulsion was applied. Mesh counts during the demonstration period ranged from 156 - 305 threads/inch. The average screen size used at this facility is 35 inches x 45 inches and 4 - 5 screens are reclaimed daily.

Screen Reclamation Area in Facility 15

Ink removal is primarily done at the press and screen reclamation is done in a back-lit spray booth. The temperature during the observer's visit was 58°F (and 50% relative humidity). Rags used for ink removal and screen reclamation are washed by an industrial

laundry service. Waste water from the high-pressure wash of the emulsion remover and haze remover is not filtered at this facility.

Current Screen Reclamation Products at Facility 15

For ink removal, Facility 15 uses acetone, as well as a proprietary product sold by a manufacturer not participating in the performance demonstration. The MSDS states that this product contains no carcinogens, no ingredients with TLVs or PELs, and no petroleum derivatives. For emulsion removal, they use a proprietary aqueous mixture with at least sodium periodate. Their standard haze remover is an aqueous blend consisting of potassium hydroxide (27%) and tetrahydrofurfuryl alcohol (11%).

Current Screen Reclamation Practices in Facility 15

Gloves, eye protection, and aprons are worn during screen reclamation. The screen reclamation process at Facility 15 is described below:

- Ink Remover: Card off the excess ink at the press. Pour lacquer thinner onto a reusable rag and wipe the screen. Bring the screen to the sink, wet it down, and let it sit for 30 seconds to five minutes. Pressure wash (1500 psi) to remove the blockout.

- Emulsion Remover: Spray product onto the screen and rub it in with a scrubber pad. Let the screen sit for 10 seconds to 5 minutes. Pressure rinse. Spray on more product where needed, rub in with the scrubber pad, pressure rinse and allow the screen to air dry. When the screen is dry, pour acetone onto a rag and wipe the screen and the frame to remove any remaining ink. Wipe again with a clean, lint-free disposable rag. Pressure wash.

- Haze Remover: After emulsion removal, a haze remover is used only if needed (on approximately 5% of the screens). When haze remover is used, the acetone wash step is eliminated. Haze remover is applied using a scraper, followed by a high pressure water spray.

Cost

Table V-178
Method 2: Summary of Cost Analysis for Alternative System Zeta

Cost Element Description		Baseline (Traditional System 4)	Alternative System Zeta		
			Facility 6	Facility 7	Facility 15
Facility Characteristics					
Average screen size (in^2)		2,127	3,926	3,060	2,084
Average # screens/day		6	13	11	5
Cost Elements per Screen					
Labor	Time spent applying, scrubbing, and removing reclamation products (min)	24.4	17.6	21.0	32.8
	Cost ($)	5.33	3.85	4.59	7.18
Materials and Equipment	# of rags used	3	0.0	3.8	0.0
	Cost ($)	0.45	0.00	0.56	0.00
Reclamation Product Use	Ink Remover Average Volume (oz.)	8.0	8.3	8.5	3.0
	Cost ($)	0.22	1.50	1.53	0.54
	Emulsion Remover Average Volume (oz.)	3.5	6.5	1.3	4.1
	Cost ($)	0.13	0.23	0.04	0.15
	Haze Remover Average Volume (oz.)	3.0	2.8	2.0	2.3
	Cost ($)	0.12	0.64	0.47	0.55
Hazardous Waste Disposal	Amount (g)	34	115	90	61
	Cost ($)	0.02	0.08	0.07	0.04
Totals					
Total Cost ($/screen)		6.27	6.31	7.26	8.46
	Normalized[a]	6.27	5.39	6.51	8.99
Total Cost ($/year)		9,399	19,704	19,973	9,521
	Normalized[a]	9,399	8,080	9,772	13,479

[a]Normalized values adjust product usage, number of screens cleaned, and number of rags laundered at demonstration facilities to reflect the screen size and number of screens cleaned per day under the baseline scenario. Labor costs, however, are not normalized. Normalization allows a comparison between the baseline and facility results.

Note: For additional information regarding product performance see performance demonstration summaries.

Method 3: SPAI Workshop Process

Method 3 (illustrated in Figure V-4) is taught as an alternative method of screen reclamation by the technical staff at the Screen Printing Association International (SPAI) in screen printing workshops. Information provided by SPAI staff was used to document this alternative method. The process for Method 3 is detailed below:

Method 3 Process

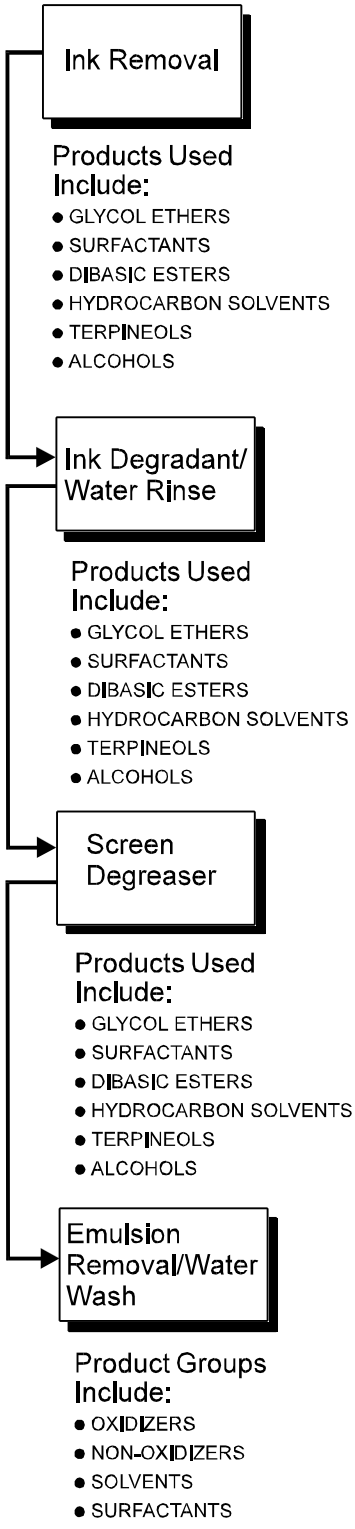
- Clean the screen with the ink remover product to remove the majority of the ink residue from the screen.
- Prior to the screen coming in contact with water, spray the screen on both sides of the stencil with an ink degradant or ink solubilizer.
- Scrub the stencil with a soft brush on both sides to break down the components of the ink. Water wash the emulsion off the screen.
- To remove the oily film that covers the screen, spray screen degreaser on both sides of the stencil and wipe off with rags.
- Apply (spray) emulsion remover and rinse screen with water.

SPAI staff state that the main advantage of this method is that it eliminates the use of a haze remover; caustic haze removers can damage the screen mesh, limiting the future use of the screen. Screen printers can also avoid exposure to the harsh chemicals that can be used in haze removal.

Because the manufacturer of Alternative System Omicron supplied a screen degreaser formulation along with other product formulation information, System Omicron, minus the haze remover product, was used as the one alternative system in Method 3. In order to evaluate Method 3 as an alternative screen reclamation method, several assumptions were used in the risk and cost assessment. It was not possible to make these assumptions based on an actual performance demonstration of Method 3. Although the demonstration of the effectiveness of this method was one of the original intentions of the performance demonstration, logistical problems prevented a performance evaluation. The assumptions used in the assessment of Method 3 are as listed below:

- In total, this process takes approximately the same amount of time as Screen Reclamation Method 2
- For the ink degradant and the screen degreaser products, about 3 oz. of each product is used per screen size of approximately 2100 in^2.
- The ink remover and the ink degradant have the same chemical composition (no ink degradant was supplied for the performance demonstration)
- Some of the parameters from the Method 2 evaluation of System Omicron were used in the cost estimation, including labor costs and quantities of ink and emulsion removers used (reference Chapter 3 methodology).

Figure V - 4
Process Steps Included in Method 3



In this assessment of Method 3 using System Omicron (minus haze remover), there is no comparable assessment of a traditional system of screen reclamation products. Reference Methods 1 and 2 for a determination of the occupational and population risks, as well as performance, of a traditional screen reclamation product system.

System Omicron Formulation

Ink Remover:	Diethylene glycol butyl ether
	Propylene glycol
Ink Degradant:	Diethylene glycol butyl ether
	Propylene glycol
Screen Degreaser:	Isopropanol
	Ethoxylated nonylphenol
	Water
Emulsion Remover:	Sodium periodate
	Ethoxylated nonylphenol
	Water

Occupational Exposure

Table V-179
Occupational Exposure Estimates for Method 3, Alternative System Omicron

System	Inhalation (mg/day)				Dermal (mg/day)	
	I	II	III	IV	Routine	Immersion
Ink Remover						
Diethylene glycol butyl ether	0	0	0	0	984	4590
Propylene glycol	17	0.1	0	0.4	576	2690
Ink Degradant						
Diethylene glycol butyl ether	0	0	0	0	984	4590
Propylene glycol	17	0.1	0	0	576	2690
Degreaser						
Isopropanol	2	2	1	0	16	73
Ethoxylated nonylphenol	0	0	0	0	47	218
Water	0	0	0	0	1500	6990
Emulsion Remover						
Sodium periodate	0	0	0	0	47	218
Ethoxylated nonylphenol	0	0	0	0	31	146
Water	0	0	0	0	1480	6920

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry

Occupational Risk Conclusions and Observations

Ink Remover/Ink Degradant/Screen Degreaser

- Margin-of-exposure calculations indicate clear concerns for chronic dermal exposures to workers using diethylene glycol butyl ether in ink removal.

- Margin-of-exposure calculations also show possible concerns for developmental toxicity risks from dermal "immersion" exposures to diethylene glycol butyl ether. Routine dermal exposures, however, represent a very low concern for developmental toxicity risks.

Table V-180
Occupational Risk Estimates for Method 3, Alternative System

Name	Hazard Quotient[b]			Margin Of Exposure[a]					
		Dermal		Inhalation		Dermal			
						Routine		Immersion	
	Inhalation	Routine	Immersion	NOAEL[c]	LOAEL[d]	NOAEL	LOAEL	NOAEL	LOAEL
Ink Remover									
Diethylene glycol butyl ether	NA	NA	NA	NA	NA	140	3.6	30	0.8
Propylene glycol	0.01	0.4	1.9	NA	NA	NA	NA	NA	NA
Ink Degradant									
Diethylene glycol butyl ether	NA	NA	NA	NA	NA	140	3.6	30	0.8
Propylene glycol	0.01	0.4	1.9	NA	NA	NA	NA	NA	NA
Degreaser									
Isopropanol	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ethoxylated nonylphenol	NA	NA	NA	NA	NA	NA	NA	NA	NA
Water	NA	NA	NA	NA	NA	NA	NA	NA	NA
Emulsion Remover									
Sodium periodate	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ethoxylated nonylphenol	NA	NA	NA	NA	NA	NA	NA	NA	NA
Water	NA	NA	NA	NA	NA	NA	NA	NA	NA

[a]Margin of Exposure (MOE) values above 100 for a NOAEL and 1000 for a LOAEL indicate low risk.
[b]Hazard Quotient is the ratio of the estimated chronic dose/exposure level to the Reference Dose (RfD) or the Reference Concentration (RfC). Hazard Quotient values less than 1 imply that adverse effects are very unlikely to occur.
[c]NOAEL means No Observed Adverse Effect Level.
[d]LOAEL means Lowest Observed Adverse Effect Level.

- Hazard quotient calculations for inhalation and dermal exposures to propylene glycol during ink removal indicate very low concern.

- Inhalation exposures to other components are very low.

- Risks from other components could not be quantified because of limitations in hazard data, although dermal exposures to all components could be relatively high.

Emulsion Removers (All systems)

- All of the systems that employ an emulsion remover use either a strong oxidizer such as hypochlorite or periodate or a strong base such as sodium hydroxide. The haze removers in Alpha, Epsilon, Gamma, Mu, Omicron, and Theta also contain these compounds. All of these materials present a high concern for skin and eye irritation and tissue damage if workers are exposed in the absence of proper protective clothing. None of the emulsion removers present significant inhalation risks.

Environmental Releases

Table V-181
Environmental Release Estimates in Screen Cleaning Operations
Method 3, Alternative System Omicron

System	Release Under Each Scenario (g/day)						
	I			II	III	IV	
	air	water	land	air	air	air	water
Ink Remover							
Diethylene glycol butyl ether	0	0	440	0	0	0	852
Propylene glycol	35	0	222	0.2	0.1	0.7	497
Ink Degradant							
Diethylene glycol butyl ether	0	330	0	0	0	0	0
Propylene glycol	35	158	0	0.2	0.1	0	0
Screen Degreaser							
Isopropanol	4.2	1	0	4.1	2	0	0
Ethoxylated nonylphenol	0	16	0	0	0	0	0
Water	0	510	0	0	0	0	0
Emulsion Remover							
Sodium periodate	0	19	0	0	0	0	0
Ethoxylated nonylphenol	0	13	0	0	0	0	0
Water	0	603	0	0	0	0	0

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry.

Environmental Release Estimates from Screen Reclamation Processes
Screen Reclamation Method 3, Alternative System Omicron

From Ink Removal Operations:

Diethylene glycol butyl ether

852 g/day to water from rags at commercial laundry

440 g/day to landfill

Propylene glycol
36 g/day to air
497 g/day to water from rags at commercial laundry
222 g/day to landfill

From Screen Degreaser Operations:
Isopropanol
10.3 g/day to air
1 g/day to water

Ethoxylated nonylphenol
16 g/day to water

From Ink Degradant Operations
Diethylene glycol butyl ether
330 g/day to water

Propylene glycol
35.3 g/day to air
158 g/day to water

From Emulsion Removal Operations
Sodium periodate
19 g/day to water
Ethoxylated nonylphenol
13 g/day to water

Table V-182
Summary of Estimated Daily Environmental Releases from a Hypothetical Facility Using Screen Reclamation Method 3, Alternative System Omicron

Substance:	To Air:	To Water:	To Landfill:
Diethylene glycol butyl ether		330 g/day 852 g/day at laundry	440 g/day
Propylene glycol	71.3 g/day	158 g/day 497 g/day at laundry	222 g/day
Isopropanol	10.3 g/day	1 g/day	
Ethoxylated nonylphenol		29 g/day	
Sodium periodate		19 g/day	

Table V-183
Estimated Releases to Water from Traditional Formulations from Screen Reclamation at a Single Facility Using Screen Reclamation Method 3, Alternative System Omicron

Substance	Amount Released to Water from Facility	Waste water Treatment Removal Efficiency	Amount to Water After Waste water Treatment	Daily Stream Concentration, ug/L[a] for 1000 MLD Receiving Water
Diethylene glycol butyl ether	330 g/day 852 g/day at laundry	83 %	56.1 g/day 145 g/day	6×10^{-2} 1×10^{-1}
Propylene glycol	158 g/day 497 g/day at laundry	97 %	4.7 g/day 14.9 g/day	5×10^{-3} 1×10^{-2}
Isopropanol	1 g/day	83 %	0.2 g/day	2×10^{-4}
Ethoxylated nonylphenol	29 g/day	100 %	0	0
Sodium periodate	19 g/day	100 %	0	0

[a]ug/L is Micrograms per liter, which is parts per billion for a substance in water. MLD is Million liters per day.

Releases to Air from Individual Screen Printing Facilities

Table V-184
Air Release, Concentration and Potential Dose Estimates from a Single Model Facility
Using Screen Reclamation Method 3, Alternative System Omicron

Substance	Amount of Releases per day	Highest Average Concentration 100 M away	Annual Potential Dose, mg/year[a]
Propylene glycol	71.3 g/day	1.5×10^{-1} ug/m^3	1
Isopropanol	10.3 g/day	2×10^{-2} ug/m^3	1×10^{-1}

[a]This estimates doses for people living 100 Meters from the hypothetical facility. The actual number of people who would fall into this range can be determined from census data, if the facility location is known. The model used to calculate concentrations is more completely explained in the Overview by Media-Air Section in Chapter III. To calculate the annual potential dose, the concentration is multiplied by the amount a person will breathe (20 m^3/day) and the number of days per year (365), and the units are converted to mg/year by dividing by 1000.

General Population Risk Conclusions And Observations

- Health risks to the general population from both air and water exposures are very low for Method 3, SPAI Workshop Process.

Although air releases were evaluated for only a single facility, it is very unlikely that an analysis of cumulative air releases would lead to different risk conclusions. Examples of general population exposure and risk estimates are shown for Method 2, Traditional System 1 in Methods 1 and 2 and Alternative System Chi in Method 2; please reference these sections as illustrative examples. Hazard Quotient values below one indicate very low risk. Margin-of-Exposure (MOE) values above 100 for a NOAEL or above 1000 for a LOAEL indicate very low risk.

Ecological Risks From Water Releases Of Screen Reclamation Chemicals

- None of the single facility releases of Method 3, SPAI Workshop Process reach an ecotoxicity concern concentration.

Performance

Due to resource constraints in this project, it was not possible to demonstrate the effectiveness of Method 3. However, the Screen Printing Association International can be contacted for information on how this method performs.

Cost

Table V-185
Summary of Cost Analysis for Method 3, Alternative System Omicron

Description		Baseline (Traditional System 4)	Alternative System Omicron[a]
Facility Characteristics			
Average screen size (in^2)		2,127	2,127
Average # screens/day		6	6
Cost Elements per Screen			
Labor	Time spent applying, scrubbing, and removing reclamation products (min) Cost ($)	24.4 5.33	17.9 3.92
Materials and Equipment	# of rags used Cost ($)	3 0.45	2.25 0.34
Reclamation Product Use	Ink Remover Average Volume (oz.) Cost ($)	8.0 0.22	4.87 0.37
	Emulsion Remover Average Volume (oz.) Cost ($)	3.5 0.13	4.33 0.33
	Haze Remover Average Volume (oz.) Cost ($)	3.0 0.12	--- ---
	Degreaser Average Volume (oz.) Cost ($)	--- ---	3.0 0.21
	Degradant Average Volume (oz.) Cost ($)	--- ---	3.0 0.23
Hazardous Waste Disposal	Amount (g) Cost ($)	34 0.02	0 0.00
Totals			
Total Cost ($/screen)		6.27	5.57
Total Cost ($/year)		9,399	8,358

[a]Alternative reclamation system costs were estimated using a combination of performance demonstration results from facilities testing product system Omicron and from SPAI on the SPAI Workshop Process.

Method 4: Alternative Screen Reclamation Technology using High-Pressure Water Blaster

Method 4 is currently in use at some screen printing facilities as an alternative to traditional screen reclamation. Method 4 utilizes the action of a high-pressure water blaster (3000 psi) so that the need for ink removal chemicals is eliminated (see Figure V-5). Emulsion and haze remover chemicals are still applied to the screen, and the water blaster also aids in removal of stencil and haze. Because an ink remover is not used in screen reclamation in Method 4, source reduction, the highest priority in the pollution prevention hierarchy, is achieved. However, simply because the ink remover is not used does not mean that occupational and population risk is low. The intrinsic hazard of the particular chemicals used in emulsion and haze remover products must be combined with worker and general exposure to the chemicals to generate a risk assessment. In the following discussion of Method 4, data detailing occupational and population exposure are presented to support overall risk conclusions for a system designated Alternative System Theta. One manufacturer supplied the actual technology and chemicals, as well as chemical formulations, for use in Method 4. The process for Method 4 is detailed below:

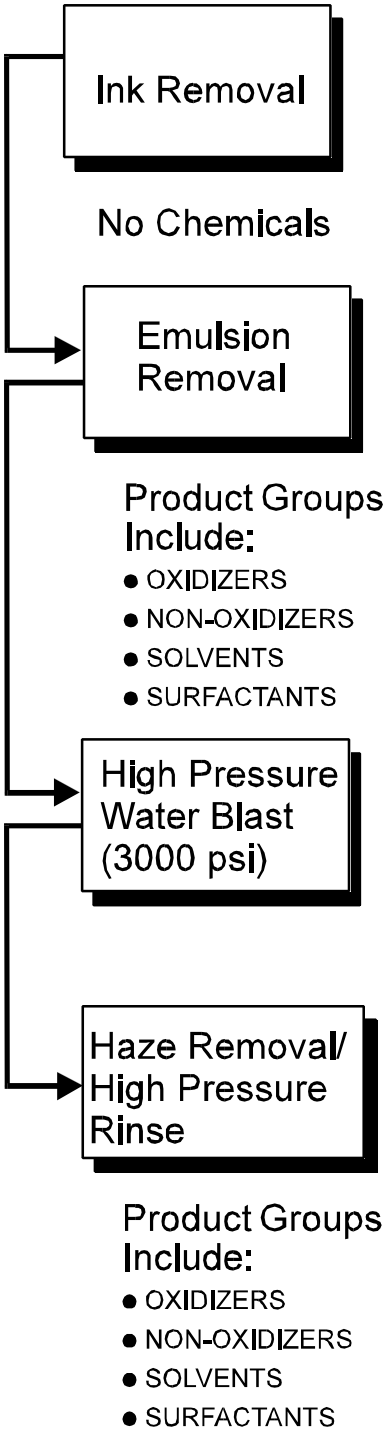
Method 4 Process

- Remove excess ink from the screen surface; do not apply ink remover.
- Spray emulsion remover on the print side of the screen. Allow to work for 10-30 seconds. Wash both sides of the screen from top to bottom with a 3000 psi pressure wash to remove ink and stencil residue.
- Apply haze remover to screen with a rag soaked in product. Allow screen to set for 3 minutes. Rinse screen with 3000 psi water blaster from the bottom to the top on the print side of the screen. Reverse screen and rinse on the ink side.

The manufacturer suggests that the following equipment is necessary for the use of this technology: washout booth with backlight capability, high-pressure washing system, spray wand with pattern control nozzle, dual low pressure chemical applicator system. As in all screen reclamation methods, printers should consider the composition of the reclamation effluent and whether it meets federal, state and local regulations for discharges to sewer or septic tanks. Because this method involves the use of large quantities of water, energy and natural resource issues should also be considered. Reference Chapter 7 for a discussion of this topic.

In this assessment of Method 4 using Alternative Technology Theta, there is no comparable assessment of a traditional system of screen reclamation products. Reference Methods 1 and 2 for a determination of the occupational and population risks, as well as performance, of a traditional screen reclamation product system.

Figure V - 5
Process Steps Included in Method 4



Alternative Technology Theta Chemical Formulations

Ink Remover:	None
Emulsion Remover:	Sodium periodate
	Water
Haze remover:	Cyclohexanone
	Furfuryl alcohol
	Alkali/caustic

Occupational Exposure

Table V-186
Occupational Exposure Estimates for Method 4, Alternative System Theta

System	Inhalation (mg/day)				Dermal (mg/day)	
	I	II	III	IV	Routine	Immersion
Emulsion Remover[a]						
Sodium periodate	0	0	0	0	1250	5820
Water	0	0	0	0	312	1460
Emulsion Remover (diluted 1:3)						
Sodium periodate	0	0	0	0	312	1460
Water	0	0	0	0	1250	5820
Haze Remover						
Alkali/Caustic	0	0	0	0	515	2400
Cyclohexanone	25	0.3	0	0	515	2400
Fufural alcohol	0	0	0	0	530	2480

[a]This system can be used with or without diluted emulsion remover, depending on the needs of the facility.

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry

Occupational Risk Conclusions and Observations

Haze remover

- Hazard quotient calculations indicate marginal concerns for chronic dermal exposures and very low concern for chronic inhalation exposures to cyclohexanone during haze removal.

Table V-187
Occupational Risk Estimates for Method 4, Alternative System Theta

	Hazard Quotient[b]			Margin Of Exposure[a]					
						Dermal			
		Dermal		Inhalation		Routine		Immersion	
Name	Inhalation	Routine	Immersion	NOAEL[c]	LOAEL[d]	NOAEL	LOAEL	NOAEL	LOAEL
Emulsion Remover									
Sodium periodate	NA	NA	NA	NA	NA	NA	NA	NA	NA
Water	NA	NA	NA	NA	NA	NA	NA	NA	NA
Emulsion Remover (diluted 1:3)									
Sodium periodate	NA	NA	NA	NA	NA	NA	NA	NA	NA
Water	NA	NA	NA	NA	NA	NA	NA	NA	NA
Haze Remover									
Alkali/Caustic	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cyclohexanone	0.07	1.5	6.8	196	NA	NA	NA	NA	NA
Furfuryl alcohol	NA	NA	NA	NA	NA	NA	NA	NA	NA

[a]Margin of Exposure (MOE) values above 100 for a NOAEL and 1000 for a LOAEL indicate low risk.
[b]Hazard Quotient is the ratio of the estimated chronic dose/exposure level to the Reference Dose (RfD) or the Reference Concentration (RfC). Hazard Quotient values less than 1 imply that adverse effects are very unlikely to occur.
[c]NOAEL means No Observed Adverse Effect Level.
[d]LOAEL means Lowest Observed Adverse Effect Level.

- Margin-of-exposure calculations show low concern for developmental and reproductive toxicity risks from inhalation exposures to cyclohexanone. Reproductive and developmental toxicity risks from dermal exposures to cyclohexanone could not be quantified.

- Inhalation exposures to other components are very low.

- Risks from other haze remover components could not be quantified because of limitations in hazard data, although dermal exposures to all components could be relatively high.

Emulsion Removers (All systems)

All of the systems that employ an emulsion remover use either a strong oxidizer such as hypochlorite or periodate or a strong base such as sodium hydroxide. The haze removers in Alpha, Epsilon, Gamma, Mu, Omicron, and Theta also contain these compounds. All of these materials present a high concern for skin and eye irritation and tissue damage if workers are exposed in the absence of proper protective clothing. None of the emulsion removers present significant inhalation risks.

Environmental Releases

Table V-188
Environmental Release Estimates in Screen Cleaning Operations
Method 4, Alternative System Theta

System	Release Under Each Scenario (g/day)						
	I			II	III	IV	
	air	water	land	air	air	air	water
Emulsion Remover							
Sodium periodate	0	177	0	0	0	0	0
Water	0	44	0	0	0	0	0
Emulsion Remover (diluted 1:3)							
Sodium periodate	0	44	0	0	0	0	0
Water	0	177	0	0	0	0	0
Haze Remover							
Alkali/Caustic	0	291	0	0	0	0	0
Cyclohexanone	53	239	0	0.7	0.4	0	0
Fufural alcohol	0	300	0	0	0	0	0

Table V-188
Environmental Release Estimates in Screen Cleaning Operations
Method 4, Alternative System Theta

System	Release Under Each Scenario (g/day)						
	I			II	III	IV	
	air	water	land	air	air	air	water

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = storing waste rags in a drum and transferring them to a laundry.

Table V-189
Summary of Estimated Daily Environmental Releases from a Hypothetical Facility
Using Screen Reclamation Method 4, Alternative System Theta

Substance:	To Air:	To Water:	To Landfill:
Sodium periodate		44 g/day	
Alkali/caustic		291 g/day	
Cyclohexanone	54.1 g/day	239 g/day	
Furfural alcohol		300 g/day	

Releases to Water from a Single Facility

Table V-190
Estimated Releases to Water from Traditional Formulations from Screen Reclamation at a Single Facility Using Screen Reclamation Method 4, Alternative System Theta

Substance	Amount Released to Water from Facility	Waste water Treatment Removal Efficiency	Amount to Water After Waste water Treatment	Daily Stream Concentration, ug/L[a] for 1000 MLD Receiving Water
Sodium periodate	44 g/day	100 %	0	0
Alkali/caustic	291 g/day	100 %	0	0
Cyclohexanone	239 g/day	83 %	41 g/day	4×10^{-2}
Furfural alcohol	300 g/day	97 %	9 g/day	9×10^{-3}

[a]ug/L is Micrograms per liter, which is parts per billion for a substance in water. MLD is Million liters per day.

Releases to Air from Individual Screen Printing Facilities

Table V-191
Air Release, Concentration and Potential Dose Estimates from a Single Model Facility Using Screen Reclamation Method 4, Alternative System Theta

Substance	Amount of Releases per day	Highest Average Concentration 100 M away	Annual Potential Dose, mg/year[a]
Cyclohexanone	54.1 g/day	1.1×10^{-1}	8×10^{-1}

[a]This estimates doses for people living 100 Meters from the hypothetical facility. The actual number of people who would fall into this range can be determined from census data, if the facility location is known. The model used to calculate concentrations is more completely explained in the Overview by Media-Air Section in Chapter III. To calculate the annual potential dose, the concentration is multiplied by the amount a person will breathe (20 m^3/day) and the number of days per year (365), and the units are converted to mg/year by dividing by 1000.

General Population Risk Conclusions And Observations

- Health risks to the general population from both air and water exposures are very low for Method 4, Alternative Screen Reclamation Technology using High Pressure Water Blaster.

Although air releases were evaluated for only a single facility, it is very unlikely that an analysis of cumulative air releases would lead to different risk conclusions. Examples of general population exposure and risk estimates are shown for Method 2, Traditional System 1 in Methods 1 and 2 and Alternative System Chi in Method 2; please reference these sections as illustrative examples. Hazard Quotient values below one indicate very low risk. Margin-of-Exposure (MOE) values above 100 for a NOAEL or above 1000 for a LOAEL indicate very low risk.

Ecological Risks From Water Releases Of Screen Reclamation Chemicals

- None of the single facility releases of Method 4, Alternative Screen Reclamation Technology using High Pressure Water Blaster.

Performance

General Summary of Alternative Reclamation Technology Theta Performance

The performance of the Alternative Technology Theta was demonstrated at Facility 1 under conditions similar to those used at SPTF for alternative system testing. This facility, however, demonstrated the performance of an alternative screen reclamation technology, instead of an alternative chemical system. The alternative technology demonstrated was a high pressure wash system with a 3000 psi spray applicator. When reclaiming screens with System Theta, an emulsion remover and a haze remover are used, but no ink remover is needed. Several different types of emulsion and haze removers are sold with this technology. The performance demonstration was conducted using the chemical products that are normally used by this volunteer facility which are supplied by the Theta equipment manufacturer. Therefore, this performance evaluation of this technology is based only on those chemicals used in the testing.

The SPTF staff felt the performance of the system was very good. During the demonstration, the ink was carded off on both sides of the screen which caused some complications during testing. Since the screen was not actually used for printing, the ink on the stencil side transferred through to the print side when the screen was carded. To remove this excess ink, the print side was also scraped. The ink on the print side of the screen was more difficult to remove and this ink also made it harder to remove the emulsion. Under normal printing operations, ink does not reach the print side of the screen, therefore SPTF staff thought this difficulty would not occur at a printing facility. The observer felt System Theta could efficiently and effectively clean the screen, while reducing the labor, effort, and quantity of chemicals required for reclamation.

Alternative Screen Reclamation Technology Theta Profile

Reclaim screens with Alternative Screen Reclamation Technology Theta as follows:

- Ink Removal and Emulsion Removal. Card up excess ink from the screen. Dilute the emulsion remover as instructed. Spray the emulsion remover on the print side of the screen. Allow to sit for 10 to 30 seconds. Wash both sides of the screen

from the bottom to the top with the 3000 psi spray applicator to remove the ink and stencil residue.

- Haze Removal. With a rag soaked in haze remover, rub the screen on the ink side and allow to set for 3 minutes. Rinse from the bottom to the top on the print side of the screen with the 3000 psi applicator. Turn the screen and rinse with System Theta equipment on the ink side. For tough stains, allow the haze remover to set for up to 10 minutes.

Alternative System Performance Evaluated by SPTF

Alternative Screen Reclamation Technology Theta was tested by SPTF on three screens (one with a solvent-based ink, one with a UV-curable ink, and one with a water-based ink). Since SPTF does not have the System Theta equipment on-site, the test was performed at a volunteer printing facility that regularly uses the Theta equipment. SPTF prepared the test screens using the same parameters as were used for the testing of alternative chemical systems (these parameters are listed in the appendix). At the printing facility, the inks were applied to the stencil side of the screen, and excess ink was carded off. However, the ink was applied for testing purposes only (screens were not used for printing) and when excess ink was carded off, it transferred to the print side of the screen. When the ink on the print side was scraped off, it spread to cover the stencil. Inks were allowed to dry for 18 hours before reclamation. The ink residue on both sides of the screen does not accurately represent the conditions in typical printing operations, however, it does represent a worst case condition. SPTF thought that the presence of ink on the print side of the screen lengthened the wash time required to remove the ink and the emulsion.

On the screen with the solvent-based ink and the screen with water-based ink, the stencil dissolved easily with the application of the high pressure water; no scrubbing was needed. There was no emulsion or ink residue left in the screen, but there was a medium ink stain remaining on the screen with solvent-based ink and a very light stain on the water-based ink screen. On both screens, all of the ink and stencil did dissolve after less than four minutes of washing with the high pressure sprayer, however, the areas of the emulsion where the ink was on the print side of the screen did not dissolve as quickly as the areas where there was no ink on the print side. SPTF staff noted that these conditions did not represent an actual printing situation well and that they did not feel that the extra time was a fault of the high pressure spray system. The haze remover completely eliminated the stains. When the haze remover was applied, the product immediately dissolved the ink stain, even before the waiting period or the pressure wash.

Results were similar for the screen with UV ink. In most areas the stencil dissolved very easily without any scrubbing. After 4 minutes of water blasting, emulsion was still present in blocks where the ink was scraped on the print side of the screen. Again, SPTF staff felt that the residual emulsion was caused by the test conditions and that it did not indicate poor performance on the part of the Theta system. Some ink stain was remaining especially in areas where the emulsion was left. The haze remover removed all of the ink, leaving only a very light stain, but the emulsion was still remaining in approximately one-third of the blocks. To remove the emulsion, the emulsion remover was reapplied and allowed to sit for 20 seconds. After water blasting the screen again, the emulsion was completely removed.

Overall, the SPTF staff present at the demonstration thought System Theta was a very efficient and effective technique for screen cleaning. Use of the system could minimize the

quantity of chemicals needed for screen reclamation by eliminating the ink remover and by using the high water pressure to reduce the quantity of emulsion and haze remover required. System Theta also reduces the labor time and effort needed to reclaim a screen.

Alternative Technology Performance Table

The following table highlights the observed performance of the Alternative Screen Reclamation Technology Theta during the product tests performed by SPTF.

Cost

Data collected by SPTF staff during a facility visit and equipment specifications provided by the manufacturer were used to develop the cost for this method. The capital cost of this equipment was annualized by the method described in Chapter 3, added to the recurring operating and maintenance costs and divided by the number of screens reclaimed per year to arrive at the per screen equipment costs. Water, wastewater and electrical usage costs were included in the cost estimate for this method only. As in all other cost estimations, the cost of a filtration system was not included as the analysis was focused on quantifying cost differences between reclamation systems, without accounting for filtration costs that may occur in all cases.

Table V-192
Alternative Screen Reclamation Technology Theta

		Performance					Demonstration Conditions			
	System Component	Avg Drying Time Before Using Product	Average Quantity Applied	Average Cleaning Time	Average Effort Required	Overall System Performance	Ink type	Emulsion type	Mesh type; Thread count	Average Screen Size
SPTF Testing at Volunteer Facility 1										
Solvent-based Ink	*Ink and Emulsion Removal*	18 hours	0.5 oz.	2.7 mins	Low	Removed stencil completely without scrubbing; where ink was put on print side of stencil, emulsion was more difficult to remove.	Solvent-based	Dual-cure direct	Polyester; 245 threads/inch	360 in^2
	Haze Remover	0 mins	1.5 oz.	1.7 mins	Low	Screen very clean; virtually no stain remaining.				
UV-curable Ink	*Ink and Emulsion Remover*	18 hours	1.0 oz.	5.5 mins	Low	Removed most of the stencil easily without scrubbing; where ink was scraped onto print side of screen, stencil residue remained.	UV-cured	Dual-cure direct	Polyester; 390 threads/inch	360 in^2
	Haze Remover	0 mins	1.5 oz.	1.5 mins	Low	No ink residue, and very light stain. Parts of emulsion remained; a second application of emulsion remover was needed.				
Water-based Ink	*Ink and Emulsion Remover*	18 hours	1.0 oz.	3.3 mins	Low	Removed stencil completely without scrubbing; where ink was put on print side of stencil, ink was more difficult to remove.	Water-based	Dual-cure direct	Polyester; 245 threads/inch	360 in^2
	Haze Remover	0 mins	1.5 oz.	1.5 mins	Low	Screen very clean; virtually no stain remaining.				

Table V-193
Method 4: Summary of Cost Analysis for Alternative Technology Theta

Cost Element Description		Baseline (Traditional System 4)	Cost Element Description	Alternative System Theta Facility 1
Facility Characteristics				
Average screen size (in^2)		2,127	Average screen size (in^2)	360
Average # screens/day		6	Average # screens/day	13
Cost Elements per Screen				
Labor	Time spent applying, scrubbing, and removing reclamation products (min) Cost ($)	24.4 5.33	Time spent pressure washing, applying and removing removing reclamation products (min) Cost ($)	5.4 1.18
Materials and Equipment	# of rags used Cost ($)	3 0.45	Pressure Wash Equipment Cost ($)	0.25
Reclamation Product Use	Ink Remover Average Volume (oz.) Cost ($)	8.0 0.22	Water Use (gal.) Electricity Use (kWhr) Utility Cost ($)	10.7 0.65 0.11
	Emulsion Remover Average Volume (oz.) Cost ($)	3.5 0.13	Emulsion Prep Product Average Volume (oz.) Cost ($)	0.8 0.11
	Haze Remover Average Volume (oz.) Cost ($)	3.0 0.12	Haze Remover Average Volume (oz.) Cost ($)	1.5 0.36
Hazardous Waste Disposal	Amount (g) Cost ($)	34 0.02	Amount (g) Cost ($)	0 0
Totals				
Total Cost ($/screen)		6.27	Total Cost ($/screen)	2.02
Normalized[a]		6.27	Normalized[a]	4.53
Total Cost ($/year)		9,399	Total Cost ($/year)	6,315
Normalized[a]		9,399	Normalized[a]	6,797

[a]Normalized values adjust product usage, number of screens cleaned, and number of rags laundered at demonstration facilities to reflect the screen size and number of screens cleaned per day under the baseline scenario. Labor costs, however, are not normalized. Normalization allows a comparison between the baseline and facility results.
[b]**No filtration system costs were included in this calculation.**

Note: For additional information regarding product performance see performance demonstration summaries.

Method 5: Automatic Screen Reclamation Technology

Automatic screen washers are commercially available technologies that remove ink, or in some cases, ink, emulsion and haze, by focusing appropriate reclamation products on a screen mesh surface within a fully enclosed unit. Limited information was available on this technology because those manufacturers who manufacture this type of equipment chose not to participate in the performance demonstration or other facets of the project. The system can be selective, in that it can be used to remove ink only, or to completely reclaim screens. These units employ a washout booth, pressurized sprayer/applicator, and filtration system to effectively remove ink; refer to Chapter 6 for a discussion of these equipment costs. Because these systems have a fully enclosed cleaning area, the amount of occupational exposure to the chemical reclamation system in use can potentially be minimized.

Features

Although the automatic screen washing technology can consist of any number of options, automatic screen washers have several basic components. The general shape for the entire unit is a large, fully enclosed, metal cube that can house a variety of screen sizes (see Figure V-6). The screen to be cleaned is placed inside the chamber and secured with clamps. When the screen is in place and the enclosure door closed, the cleaning process can begin.

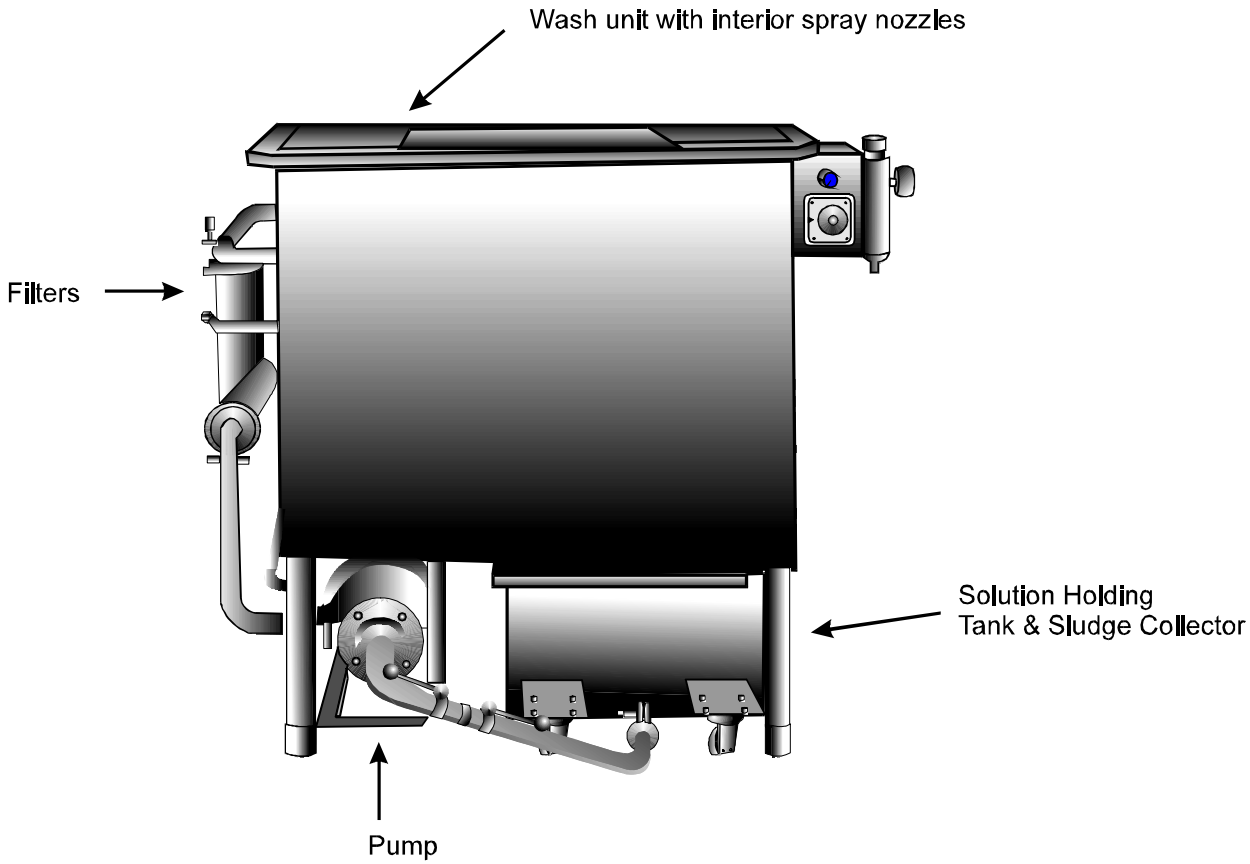
First, a mobile mechanical arm sprays solvent through one or more pressurized applicator nozzles onto the screen for any number of preset cleaning cycles. These applicator systems can operate in various ways depending on the system, but most apply the cleaner at pressures ranging from 30 psi to 150 psi (see Chapter 6 for further information on pressurized applicator systems). The used solvent then drains off the screen and usually drops directly into the filtration system. The effluent travels through the filtration system to remove the contaminants from the waste stream, and the recycled solvent can often be recirculated for subsequent use. These filtration and recirculation systems are available with various specifications and options and are discussed in more detail in Chapter 6.

While this is the generic washing system for ink removal, many other variations are currently available. One available option is multi-stage ink removal. Some automatic screen washers are equipped to remove the ink in several stages or cycles such as washing, rinsing, or blowing, and equipment employing any or all of these cycles are available. In such a system, the ink would be completely washed out in the first cycle, rinsed again to remove stubborn residue, and blown dry using air pressure. Automatic screen washers are also available to remove emulsion and haze, as well as ink, from screens. The general process for this is to apply an emulsion remover to the screen (usually with hot water and a spray applicator) after ink removal is complete; the screen is then pressure-washed and rinsed with water. A haze remover can then be applied with a spray applicator. For more specific information on automatic screen washing units, printers should consult manufacturers, product literature, and other printers.

Feasibility

The automatic screen washing systems may not be a feasible option for a large segment of the screen printing industry because they are predominantly manufactured for larger reclaiming operations. The size and speed of these systems allow a printer to remove the ink from large quantities of screens in a very short period of time; most systems can clean a screen

Figure V-6
The Typical Exterior of an Automatic Screen Washing System Used for Ink Removal



in under five minutes. In addition, the cost of an automatic screen washing system can discourage most small printers from purchasing one. Some automatic systems that remove only ink can be purchased for approximately $5,000 to 7,000; the majority of these units cost between $15,000 and 30,000. The more expensive units may include emulsion and haze removal. Such a high cost for reclamation equipment may make automated screen systems an implausible method of screen reclamation for smaller printers. On the other hand, those printers willing to pay the cost for such a technology can largely dictate the exact specifications needed; an automatic system can be created to suit the need of virtually any facility. The size of an automated system may vary to allow screens as large as 60"x 70" to be cleaned. These units may also have multiple interior cleaning areas.

Evaluation

Due to the lack of manufacturer participation, the demonstration of the performance of an automatic screen washer was not undertaken. However, a risk assessment was developed for an automatic screen washing system used by a facility that participated in the performance demonstration; this particular screen washer only removed ink. Experimental parameters

used in the occupational exposure and population exposure calculations were drawn from the data available from this single site. Because the manufacturer of the ink remover product used in the screen washer did not participate in the project, the formulation for the ink remover was not available (considered proprietary). The risk assessment could not be undertaken for the actual solvents used in the screen washer because the composition of the ink remover was unknown. The experimental parameters for the screen washer were instead used with two other ink removers, mineral spirits and lacquer thinner, to develop a risk assessment. These two ink removers were also assessed in screen reclamation in Methods 1 and 2 as components of Traditional Systems 1 and 3.

Process Description

This automatic screen washer is an enclosed system used for ink removal only. It consists of two tanks, a wash tank and a rinse tank, each with 35 gallons of the same solvent. The screens are held stationary in the washer machine while an arm with spray nozzles moves up and down the stationary screens, spraying ink remover solvent. The solvent runs off the screen back into the tank from which it came. The machine is programmed to activate the pump for the appropriate tank (wash or rinse) at specific intervals for different spray cycles.

The wash tank gets dirtier at a quicker rate than the rinse tank because the rinse tank cleans off the screen for the last time. When the wash cycle solvent is eventually replaced, the spent solvent is pumped out of the tank into a drum and allowed to settle. The pumping is performed by opening and closing valves in the machine. The solvent on top of the sediment is pumped back into the wash tank after the sediment settles. The spent rinse solvent is pumped into the wash tank and fresh solvent is pumped into the rinse tank. According to one facility that uses an automatic screen washer, approximately 7-10 gallons of solvent are lost during 55 operating days and the bath is changed every 8-9 months. The settled sediment from the spent wash solvent is disposed of as hazardous waste.

Any solvent drippage from screens during screen removal is collected and returned to the tank. The trap in the reclamation sink generates a solids waste. According to the facility, about 0.5 pounds of waste is generated per year and disposed of as municipal waste.

Occupational Exposure and Environmental Releases

Assumptions

- The amount of occupation exposure and risk depends upon the amount of cleaner released from the automatic screen washer.
- 35 screens are cleaned per day
- Automatic cleaning for 6 minutes per screen
- Total machine operating time is 210 minutes per day
- 20 oz. per day of solvent losses occur due to volatilization

- 3 employees work with the screen washer
- 15 minutes per employee for screen removal

The exposure/release scenario includes air releases due to volatilization of the ink remover solvent during machine operation. Dermal contact of the ink remover solvent would occur during screen removal. Spent baths and solids waste from the machine trap are periodically disposed of.

EPA has evaluated occupational exposure and risk of automatic screen washers using chemical systems based on Traditional System 1 and Traditional System 3.

Table V-194
Environmental Release Estimates from Automatic Screen Washer

Solvent System	Releases to Air (g/day)
Ink remover solvent	555

Table V-195
Occupational Exposure from Automatic Screen Washer

Solvent System	Inhalation (mg/day)	Dermal (mg/day)
Ink remover solvent	266	3,900

Estimation Methodology

In operation, the automatic screen cleaner sprays the screen with solvent and then allows the screen to drip dry. This process is repeated for the rinse cycle. Releases of the solvent to the air consist of the following:

1) Volatilization from drops of the solvent as they are being sprayed toward the screen.
2) Volatilization from the screen as it drips.
3) Volatilization from the liquid solvent pool.

The first part consists of forced-convection mass transfer past a set of spheres. The second involves free convection from a vertical plate. These processes are not described by the estimation methods in the CEB manual. If the unit were open to atmosphere, equations would be needed for all of these processes. However, the unit is closed during operation, so that the three evaporation sources merely serve to saturate the vapor space in the machine. When the machine is opened, this vapor is released to the atmosphere and the workers are exposed to it. The mass of solvent in this released vapor is (assuming complete saturation of the vapor space):

$$(\frac{V}{24.45})(\frac{P}{760})M$$

where

V is the volume of the headspace (l)
P is the vapor pressure of the solvent (mmHg)
M is the molecular weight of the solvent (g/mol)

Now, we know that 8.5 gallons of solvent is lost in this way over 55 working days. At a solvent density of 0.95 g/cc, this corresponds to 555 g/day. The vapor pressure of the solvent is 3.6 mmHg. The molecular weight is probably close to 150 g/mol. Isobutyl isobutyrate, a known component of the mixture, has a molecular weight of 144 g/mol. Other compounds with the correct volatility (and we know that the solvent consists entirely of VOCs) have molecular weights in the same range. Thus, the volatilization rate of any other solvent will be:

$$555 \times (\frac{P}{3.6})(\frac{M}{150})$$

As noted in our earlier reports, the worker exposure in mg/day equals the air release in g/day times 0.48. Thus, the worker exposure in mg/day is:

$$0.48 \times 555 \times (\frac{P}{3.6})(\frac{M}{150})$$

Thus, if the total vapor pressure of any other solvent and the average molecular weight of its vapors can be computed, the airborne releases and worker exposure can be estimated.

These are worst-case estimates which assume that all of the leakage occurs during removal of the screens, and none occurs overnight or on weekends when workers are absent.

Example 1. *Estimate the air releases and environmental exposure for ink removal from 6 screens using the automatic screen washer.*

For ink remover solvent, 555 g of ink are released to air per day during the cleaning of 20 screens. For 6 screens, the amount released to air per day will be:

$$555 \text{ x } (6/35) = 95 \text{ g/day}$$

For 6 screens, the worker exposure is:

$$0.48 \text{ x } 95 = 46 \text{ mg/day}$$

Example 2. *Estimate the air releases and environmental exposure for ink removal from 6 screens using the automatic screen washer with mineral spirits as the ink remover.*

Mineral spirits (light hydrotreated) has the following physical properties:

Molecular weight:	86
Vapor pressure:	1 mm Hg
Density:	0.78 g/L

For mineral spirits, the volatilization will be:

$$95 \times (1/3.6) \times (86/150) = 15.1 \text{ g/day}$$

The worker exposure will be:

$$0.48 \times 95 \times (1/3.6) \times (86/150) = 7.3 \text{ gm/day}$$

Example 3: *Estimate the Air Releases and Environmental Exposure for Ink Removal from 6 Screens Using the Automatic Screen Washer with Lacquer Thinner as the Ink Remover.*

Occupational Risk Estimates

Quantitative risk estimates could not be determined for this system due to insufficient data. See risk conclusions for areas of concern for this system.

Occupational Risk Conclusions

Automatic Screen Washer - Mineral spirits (ink remover only)

- Inhalation exposures were significantly lower (reduced by about 70%) than the exposures during manual use of this system. Risks could not be quantified because of limitations in hazard data.
- Dermal exposures can still be relatively high.

Automatic Screen Washer - Lacquer Thinner (ink remover only)

- Hazard quotient calculations indicate marginal concerns for chronic inhalation exposures to toluene, methyl ethyl ketone, and methanol.

Table V-196
Occupational Risk Estimates for Auto Screen Washers Using Lacquer Thinner as the Ink Remover

Name	Hazard Quotient[b]			Margin Of Exposure[a]					
				Inhalation		Dermal			
		Dermal				Routine		Immersion	
	Inhalation	Routine	Immersion	NOAEL[c]	LOAEL[d]	NOAEL	LOAEL	NOAEL	LOAEL
Ink Remover									
Methyl ethyl ketone (2-butanone)	7.7	56		NA	NA	NA	NA	NA	NA
Butyl acetate normal	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methanol	1.2	5.6		NA	NA	NA	NA	NA	NA
Naphtha, light aliphatic	NA	NA	NA	NA	NA	NA	NA	NA	NA
Toluene	5.6	111		NA	NA	NA	NA	NA	NA
Isobutyl isobutyrate	NA	NA	NA	NA	NA	NA	NA	NA	NA

[a]Margin of Exposure (MOE) values above 100 for a NOAEL and 1000 for a LOAEL indicate low risk.
[b]Hazard Quotient is the ratio of the estimated chronic dose/exposure level to the Reference Dose (RfD) or the Reference Concentration (RfC). Hazard Quotient values less than 1 imply that adverse effects are very unlikely to occur.
[c]NOAEL means No Observed Adverse Effect Level.
[d]LOAEL means Lowest Observed Adverse Effect Level.

Table V-197
Estimated Air Releases and Environmental Exposure for Ink Removal Screens Using the Automatic Screen Washer with Lacquer Thinner as the Ink Remover

Lacquer Thinner	wt%	Molecular Weight	Mole fraction	Vapor pressure (mm Hg)	Partial pressure (mm Hg)	Emission	Inhalation	Dermal
Methyl ethyl ketone	30	72.11	0.34	77.50	26.43	335.23	160.91	1,170
Butyl acetate	15	116.2	0.11	12.80	1.35	27.68	13.29	585
Methanol	5	32.04	0.13	126.88	16.23	91.47	43.91	195
Naphtha, light aliphatic	20	86	0.19	20.00	3.81	57.67	27.68	780
Toluene	20	92.14	0.18	28.00	4.98	80.74	38.76	780
Isobutyl isobutyrate	10	144.21	0.06	3.20	0.18	4.61	2.21	390

- Hazard quotient calculations indicate clear concerns for chronic dermal exposures to toluene and methyl ethyl ketone and marginal concerns for dermal exposures to methanol.

- The risks described above are slightly lower than the corresponding risks during manual use of this system.

- Risks from other components could not be quantified because of limitations in hazard data, although dermal exposures to all components could be relatively high.

Table V-198
Summary of Estimated Daily Environmental Releases from a Hypothetical Facility Automatic Screen Washer, Mineral Spirits

Substance:	To Air:	To Water:	To Landfill:
Mineral Spirits	15.1 g/day		

Estimated Releases to Air from Individual Screen Printing Facilities

Table V-199
Air Release, Concentration and Potential Dose Estimates from a Single Model Facility
Automatic Screen Washer, Mineral Spirits

Substance	Amount of Releases per day	Highest Average Concentration 100 M away	Annual Potential Dose, mg/year[a]
Mineral Spirits	15.1 g/day	3×10^{-2}	2×10^{-1}

[a]This estimates doses for people living 100 Meters from the hypothetical facility. The actual number of people who would fall into this range can be determined from census data, if the facility location is known. The model used to calculate concentrations is more completely explained in the Overview by Media-Air Section in Chapter III. To calculate the annual potential dose, the concentration is multiplied by the amount a person will breathe (20 m^3/day) and the number of days per year (365), and the units are converted to mg/year by dividing by 1000.

Table V-200
Summary of Estimated Daily Environmental Releases from a Hypothetical Facility
Automatic Screen Washer, Lacquer Thinner

Substance:	To Air:	To Water:	To Landfill:
Methyl ethyl ketone	335 g/day		
n-butyl Acetate	27.7 g/day		
Methanol	91.5 g/day		
Aromatic solvent naphtha	57.7 g/day		
Toluene	80.7 g/day		
Isobutyl isobutyrate	4.6 g/day		

Table V-201
Air Release, Concentration and Potential Dose Estimates from a Single Model Facility
Automatic Screen Washer, Lacquer Thinner

Substance	Amount of Releases per day	Highest Average Concentration 100 M away	Annual Potential Dose, mg/year[a]
Methyl Ethyl Ketone	335 g/day	7×10^{-1} ug/m^3	5
n-butyl acetate	27.7 g/day	5×10^{-2} ug/m^3	4×10^{-1}
Methanol	91.5 g/day	2×10^{-1} ug/m^3	1
Naphtha, light aliphatic	57.7 g/day	1×10^{-1} ug/m^3	8×10^{-1}
Toluene	80.7 g/day	2×10^{-1} ug/m^3	1
Isobutyl isobutyrate	4.6	9×10^{-3} ug/m^3	7×10^{-2}

[a]This estimates doses for people living 100 Meters from the hypothetical facility. The actual number of people who would fall into this range can be determined from census data, if the facility location is known. The model used to calculate concentrations is more completely explained in the Overview by Media-Air Section in Chapter III. To calculate the annual potential dose, the concentration is multiplied by the amount a person will breathe (20 m^3/day) and the number of days per year (365), and the units are converted to mg/year by dividing by 1000.

General Population Risk Conclusions And Observations

- Health risks to the general population from both air and water exposures are very low for Method 5, Automatic Screen Reclamation Technology.

Although air releases were evaluated for only a single facility, it is very unlikely that an analysis of cumulative air releases would lead to different risk conclusions. Examples of general population exposure and risk estimates are shown for Method 2, Traditional System 1 in Methods 1 and 2 and Alternative System Chi in Method 2; please reference these sections as illustrative examples. Hazard Quotient values below one indicate very low risk. Margin-of-Exposure (MOE) values above 100 for a NOAEL or above 1000 for a LOAEL indicate very low risk.

Ecological Risks From Water Releases Of Screen Reclamation Chemicals

- Cumulative releases of mineral spirits present a concern for risk to aquatic species. The largest contributor to these releases is the hypothetical commercial laundry that launders the shop rags used by the area's screen printers.

- None of the other components of any of the two traditional ink removers reached an ecotoxicity concern concentration, even when considering the cumulative releases from all shops in the area.

- None of the single facility releases of the traditional ink removers reach an ecotoxicity concern concentration.

Cost

Two cost estimates were developed which reflect both the baseline facility's operations and size and the range of equipment available. Typically, automatic screen washers substitute for the ink removal step; emulsion removal and haze removal may still be required.

Automatic Screen Washer #1 is the unit used by the facility that also participated in the performance demonstration. It was a large capacity (in terms of the maximum size of screen) enclosed washer with a fully automated feed system to move the screens through separate wash and rinse areas. It was assumed that mineral spirits was present in both reservoirs. As mineral spirits are used in the ink removal step, the cost analysis of automatic screen washer #1 assumes the same emulsion and haze removal costs as in the baseline. Its original manufacturer's purchase price of $95,000 was used as a basis for the cost analysis, although in actuality, the facility purchased the equipment second-hand at auction. The only operating costs were related to solvent make-up (daily) and replacement of the reservoirs' contents 70 gallons (every eight to nine months). Time spent loading and unloading the washers was taken from manufacturer's documentation of the equipment. As the equipment's electrical rating was not available from information provided by the distributor, electrical costs were not included. The price of mineral spirits ($4.00/gallon) was taken from the Workplace Practices Questionnaire. Emulsion removal and haze removal costs were assumed to be similar to those of the baseline system.

Automatic Screen Washer #2 is a smaller unit on which some minimal information was gathered. Screens must be loaded and unloaded by hand. Because it uses a solvent with lower volatile fraction than #1, more solvent remains on the screen and must be washed off following ink removal. Time spent loading and unloading the washers was taken from manufacturer's documentation of the equipment. Two pumps operate using compressed air which is reportedly available from other sources at the facility; the cost of a generator was not included in the cost analysis. The price of the ink remover was provided by the equipment supplier. Emulsion removal costs were assumed to be similar to those of the baseline system. The manufacturer indicated that a haze remover was not required given the formulation of the ink remover.